TOPS

A NEW AMERICAN INDUSTRY

THE ARLINGTON MILLS

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A FLOCK OF SHEEP, FRANKLIN PARK, BOSTON, MASSACHUSETTS

A New American Industry

TOPS

A Study
In the Development of the
American Worsted
Manufacture

THE ARLINGTON MILLS

LAWRENCE
MASSACHUSETTS

CAMBRIDGE
Printed at the Riverside Press
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THE Arlington Woolen Mills were organized under the General Statutes of the State of Massachusetts.

The certificate of organization was filed with the Secretary of the Commonwealth, February 20, 1865.

The corporate name was changed to "Arlington Mills" by a special Act of the Legislature of 1875, Chap. 1. Approved January 25, 1875.

The Capital Stock was increased under the General Statutes,

December 3, 1877, to $500,000.

June 1, 1880, to $750,000.

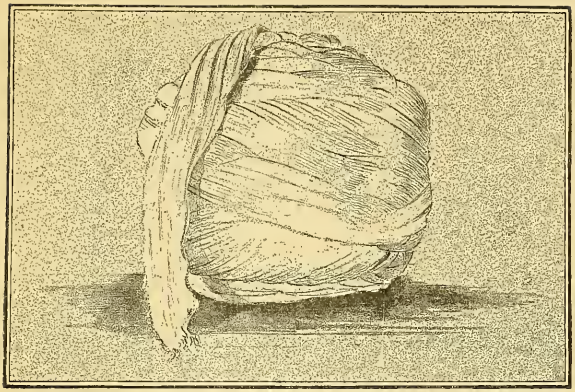
September 4, 1882, to $1,000,000.

It was increased by Special Acts of the Legislature

Of 1887, Chap. 7; approved February 8, 1887, to $1,500,000.

Of 1890, Chap. 19; approved February 12, 1890, to $2,000,000.

Of 1896, Chap. 151; approved March 19, 1896. to $2,500,000.



BY WAY OF PREFACE

MOST people have not the slightest idea what a "top" is, and some explanation to the uninitiated is a necessary preface to a book which is all about worsted tops. The word itself is a good old Anglo-Saxon word, signifying a tuft or ball at the point or top of anything, and so specifically, in the worsted manufacture, a bunch or bundle of long-stapled combed wool, or "sliver," ready for the spinner. The definition given by McLaren is "a ball of combed wool from which the noil has been separated." It is claimed that the child's toy, a top, although deriving its name from the German

word *topf*, is a kindred word; for if we were to attempt a picture of the worsted top as originally made by the hand comber, we could hardly do better than to say that it resembled in appearance the boy's top, in its pear-shaped or conoid form. Just what it looks like, in these days of machine-made tops, can be judged from the illustration above, which is sketched from a drawing of a top, as balled for sale, containing about one hundred and eighty yards of worsted sliver, and weighing about seven pounds.

It is not so easy to trace the origin of the word "noil," used to describe the short fibres rejected by the combing machine in making the top. The early English form of the word was *noyl* or *noyle;* and the Century Dictionary assigns its origin to the Old French *noiel*, *noyel*, *noel*, *nouyau*, signifying a button or buckle; Vickerman, in his lecture on "The Woolen Thread," says that the word comes from the Latin *nodus*, a knot, and that it means "knotty," or "not do." This is more ingenious than convincing. The most natural explanation of the existence of the word, in this particular application of it, is to say that like "Topsy" it just "growed," and was applied to the rejected wool fibres without any reference to etymological niceties, by the plain people who made their living, centuries ago, in the good old-fashioned

use of hand combs and furnace, preparing wool for the worsted spinners of Merry England in the days of King Edward, when the town of Norwich first came into international notoriety as the seat of the worsted manufacture. To a larger extent than any other industry, the wool manufacture has invented its own language. It is full of technical words, evolved out of the homely picturesqueness of practical facts, largely of English dialectic origin, and seeming to exactly typify in sound the things for which they stand. They offer a rich field of investigation for the trained philologist. As this publication is not a work on etymology, we will not pursue this interesting topic farther, but proceed at once to the more practical question of the relation which the top is to bear to the future development of the American wool manufacture.

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HAND COMBING
(From a Fourteenth Century MS. in British Museum)

CHAPTER I

THE GENESIS OF THE AMERICAN WORSTED MANUFACTURE

THIS book will describe the introduction of a new branch of industry into the United States, or rather, of a new phase of the worsted manufacture, — the making of worsted tops, of every variety, for sale to the spinners of worsted yarn. It will describe the buildings that have been constructed for the manufacture, and some of the novelties of method applied. It will enumerate the advantages to the manufacturer and to the country which seem to be inevitable from the establish-

Purpose of this book

GENESIS OF THE AMERICAN WORSTED MANUFACTURE

ment of this new branch of industry, and incidentally it will give information, some of it old, some of it new, about the history and development of the worsted manufacture in the United States and elsewhere; and in other ways will seek to interest as well as to instruct such readers as want to know what that industry is, what obstacles it has overcome, and what future awaits it in this country.

The time auspicious

The enterprise described in these pages is the result of plans which have been carefully maturing for years, the actual execution of which has been delayed in patient waiting for the opportune moment. That moment seems at last to have arrived; the United States, biggest and best of all the countries in the world, after a prolonged struggle with adverse conditions, which have tested the grit of her business men and proved the soundness of her business basis, is upon the eve of a great step forward, of a new industrial development, the character and extent of which will leave far in the rear all the past achievements of the nation. Our population has been steadily growing at the average rate of about 1,500,000 a year; by the time the census of 1900 is taken, it will have reached 75,000,000, representing a greater consuming power than any equal population anywhere in the world. To keep up with the requirements

of such a population, the worsted manufacture must adopt and adapt some changes of method, needed to bring it more nearly abreast of the industry in the countries where it has reached its highest development. This book aims to show that these changes are necessary, that they are already under way, and that they are about to be enormously expedited and facilitated.

GENESIS OF THE AMERICAN WORSTED MANUFACTURE

To measure intelligently the relation which this new industry hopes to sustain to the general industry of wool manufacturing in this country, it is necessary to take a preliminary glance at the history of the worsted manufacture in the United States. We shall go over the ground as briefly as possible, and dwell only lightly on facts which are familiar to those who handle wool in any of its forms.

The manufacture of wool by the factory system is only a hundred years old in the United States, nor very much older in any other country. Measured by the ordinary standards, it is still an "infant industry" among us, insomuch as it is still passing through a series of changes somewhat comparable to those which occur in the human frame as it emerges from childhood into maturity. To carry the similitude a step farther, the domestic wool manufacture may be said to be standing to-day on the threshold of its manhood, at the point at which the youth,

An infant industry

GENESIS OF THE AMERICAN WORSTED MANUFACTURE

putting aside youthful things, takes on the duties of life and starts to make his place in the world. His success in life depends upon the manner in which his faculties and muscles have been trained and his aptitudes developed. These are his tools; and if they are dull or defective, he won't make much of a fist of it. It is very much the same with an industry; beyond a certain stage, its progress and development depend upon the facilities it commands for further advance. The American wool manufacture has been lacking thus far in some of the chief facilities for a rapid and healthy progress along the line of worsted goods; until that lack is supplied, its progress is retarded like that of the defectively educated man. The new enterprise described in this volume will inaugurate a movement to supply certain facilities for the worsted manufacture that have been altogether absent in the past.

The first worsted mill

The worsted industry is very much younger here than the woolen manufacture, and very much farther behind the development it has reached in foreign countries. Indeed, we had no worsted manufacture in the United States until about 1842; and as late as 1860 it was practically confined, outside the manufacture of carpet yarns, to three large New England mills, — the Pacific, the Hamilton Woolen, and the Man-

chester, which had been organized to carry on the manufacture of mousseline delaines. These mills had their origin before the machinery for combing wool was perfected; but they gradually introduced these machines, and before the close of the civil war there were a number of them in operation in the country.

GENESIS OF THE AMERICAN WORSTED MANUFACTURE

There seems to have been an impression among those who framed our earlier tariff laws, that while the woolen manufacture was an industry of great promise, and worthy of every fostering care, the worsted manufacture was an exotic, — a branch of industry beyond attainment, and therefore unworthy of attention. Consequently, whenever a new tariff was made, worsted goods were always made dutiable at much lower rates than woolens, apparently on the theory that they were bound to be imported any way, and should therefore be burdened only with revenue duties.

A curious document

There exists in Washington a curious document submitted to the Secretary of the Treasury in 1854 by the British minister at Washington, inclosing a memorial from the Bradford Chamber of Commerce, and praying for a reduction of the then existing ad valorem duty of 25 per cent. upon worsted goods to a materially lower rate, on the ground that they "do not come into competition with American products," and that

GENESIS OF THE AMERICAN WORSTED MANUFACTURE

a material increase in their importation would therefore be "a benefit to every class and every section." The prayer of these canny Yorkshiremen was addressed to friendly ears; the duty was reduced from 25 to 19 per cent., by the act of 1857, and in consequence there ensued for the next few years a mighty increase in the development of Bradford. Her machinery doubled in capacity, and the foundations of many a princely fortune were laid, largely through the increase in American business, where there were no American mills to compete for the domestic trade.

Results of the civil war

But the civil war came on; the necessities of the government compelled higher duties all along the line; and before the war ended, conditions had arisen under which the making of many varieties of worsteds was possible here. When the war was over, our people rubbed their eyes and awakened to the fact that we actually had an American worsted manufacture, firmly established, — a sturdy child, needing only the same consideration that was extended to other industries to develop into healthy and vigorous manhood. When, therefore, Congress came to the enactment of the famous tariff of 1867, it recognized the fact that, in spite of itself almost, this great industry had been transplanted into our midst, and that with the same care bestowed

upon the woolen and cotton manufactures, it would speedily add enormously to the wealth of the nation.

We have said that the growth of the worsted manufacture has been very rapid in the United States of late years; but it is susceptible of demonstration, by a comparison of the statistics of this country and of England, that it is very far as yet from having reached the relative importance that it possesses abroad, and is destined to acquire in the United States. To make this clear, we must beg the reader's pardon while we intrude a few statistics; they are dry reading, but they have their uses nevertheless. This little table from the eleventh federal census shows the development of our worsted industry from 1860 to 1890: —

STATISTICS OF WORSTED MILLS, 1860-1890.

Years.	Number of establishments.	Capital.	Miscellaneous Expenses.	Average number of Employees.	Total Wages.	Cost of Materials used.	Value of Products.
1860	3	$3,230,000	—	2,378	$543,684	$2,442,775	$3,701,378
1870	102	10,085,778	—	12,920	4,368,857	14,308,198	22,090,331
1880	76	20,374,043	—	18,803	5,683,027	22,013,628	33,549,942
1890	143	68,085,116	$4,917,760	43,593	15,880,183	50,706,769	79,194,652

We see from this table that during the decade 1880–1890, the number of worsted mills just about doubled, the capital employed in-

creased more than three times, the total number of employees more than doubled, and the value of products increased 136 per cent. In the same decade the value of the products of the woolen mills declined from $160,606,721 to $133,577,977, showing that all the gain of the decade was in the worsted mills, and that the development of this branch was going on at the expense of the other. It was still the fact, however, that the woolen mills far outnumbered the worsted mills, exceeded them in machinery capacity, and turned out a product nearly double the value of the products of the worsted mills.

English statistics

Comparing this situation with that which exists in England, we shall find every justification for the contention that our worsted industry is still far behind its normal development, as compared with the woolen industry, when judged by the relative statistical status of the two industries in the greatest of the wool manufacturing nations. The latest returns we have on the subject are those of the British Board of Trade for 1889, and from these it appears that the total number of persons employed in the woolen and worsted industries was almost exactly the same in both branches, — 148,729 in one and 148,324 in the other; while in the woolen mills there were 3,407,002 spindles as compared with 3,072,250 worsted spindles. From the year 1870,

when these English figures begin, the worsted manufacture has been gaining steadily upon the woolen manufacture; in 1889, as we see, they were nearly neck and neck. When the next returns appear, we have no doubt they will show the worsted manufacture considerably in the lead; for the tendency towards worsteds has been more marked in the past five years than ever before. The tastes of the people are distinctly turning from woolen to worsted fabrics; and the United States manufacturers have not yet brought the worsted branch to the relative development long ago reached abroad. The field for growth is correspondingly large.

GENESIS OF THE AMERICAN WORSTED MANUFACTURE

We must not be understood as in any sense decrying the woolen manufacture, or predicting its decay. We are simply depicting an industrial evolution which, by reason of its belated start in the United States, is now bound to advance with the greater rapidity here. The field of the woolen mill has been gradually circumscribed, but it is still large enough to tax the energies of increasing numbers. The people will never stop using blankets; and, while the astonishing development of the knitted underwear manufacture has greatly limited the use of flannels in one direction, the taste and ingenuity of their makers have largely increased their use in another by producing flannel dress goods, of

The woolen manufacture

delicate finish and beautiful patterns, which must always retain their popularity for ladies' wear. Nevertheless, there are possibilities of fabrication in worsted goods, particularly in the use of lustre wools and mohairs, and in Jacquard effects, which are beyond attainment in woolens, and which, as the application of art to textiles extends, are destined to greatly increase the use of worsteds, not only for ladies' wear, but for every conceivable decorative purpose.

The Arlington Mills begins to make worsted

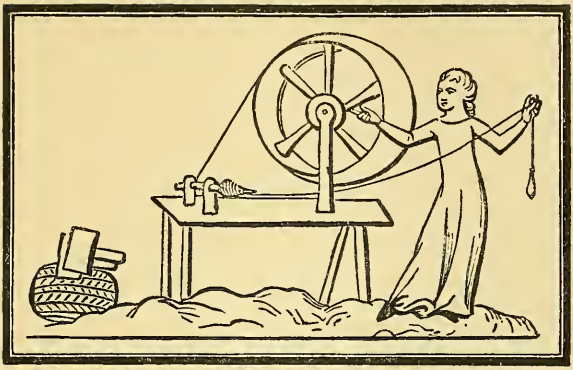
It may thus be said to be more the result of accident than design that we have a worsted manufacture in this country, and we count it a happy coincidence that the Arlington Mills came permanently under the present management very shortly after the passage of that celebrated tariff act of 1867. The mills had hitherto been employed upon various kinds of woolen goods, including felts, and had not been particularly successful. But its management was quick to see the possibilities opened up by the act of 1867, and decided to abandon woolen goods altogether. No worsted machinery of any kind was then manufactured in this country, — indeed, very little of it is made here yet, and great possibilities await the men with the courage and the capital necessary to successfully enter this field of enterprise. Combing, preparing, and spinning machinery were therefore imported

from England, enough to supply the yarns for 160 looms.

Nothing but discouragement rewarded the earlier years of the enterprise. In England, France, and Belgium the worsted manufacture had by this time been brought to a very high degree of perfection, and worsted dress goods were landed here at prices and of qualities which were the wonder and the despair of American pioneers. Skilled operatives were few; the whole business was experimental; and money was spent much faster than it came back. In 1869 it was found that the Arlington Company must either reorganize or suspend. It required a good deal of courage, on the part of the stockholders, to pay into the treasury the full amount of the capital stock, then $240,000, and continue operations. But that was done, and the venture was justified in a comparatively short time, by the popularity of the lustre fabrics, mohairs, alpacas, and other bright goods, which was at that time very great, and to the manufacture of which the Arlington Mills gradually turned all its energies.

It is not our purpose in this volume to repeat the history and description of the Arlington Mills contained in the book entitled "The Arlington Mills: A Historical and Descriptive Sketch," published in 1891. The account here

given relates only to new buildings erected and new processes introduced since that volume was published; and the reader desiring further information in regard to the mill and its products is referred to the book in question. It will appear, from that volume, that the forward step now taken in the development of the enterprise is the logical outcome of its previous growth.



HAND SPINNING
(From a Fourteenth Century MS. in British Museum)

CHAPTER II

THE SPECIALIZATION OF THE WORSTED INDUSTRY

WE have gone thus fully into the history of our domestic worsted manufacture, because it is important to a full understanding of the revolution in methods of manufacture which is destined ultimately to overtake this industry in the United States. It is still an industry in the chrysalis state; it is to emerge from that state into the full and final form of development, not suddenly or readily, as occurs to the chrysalis in nature, but slowly and pain- An evolution

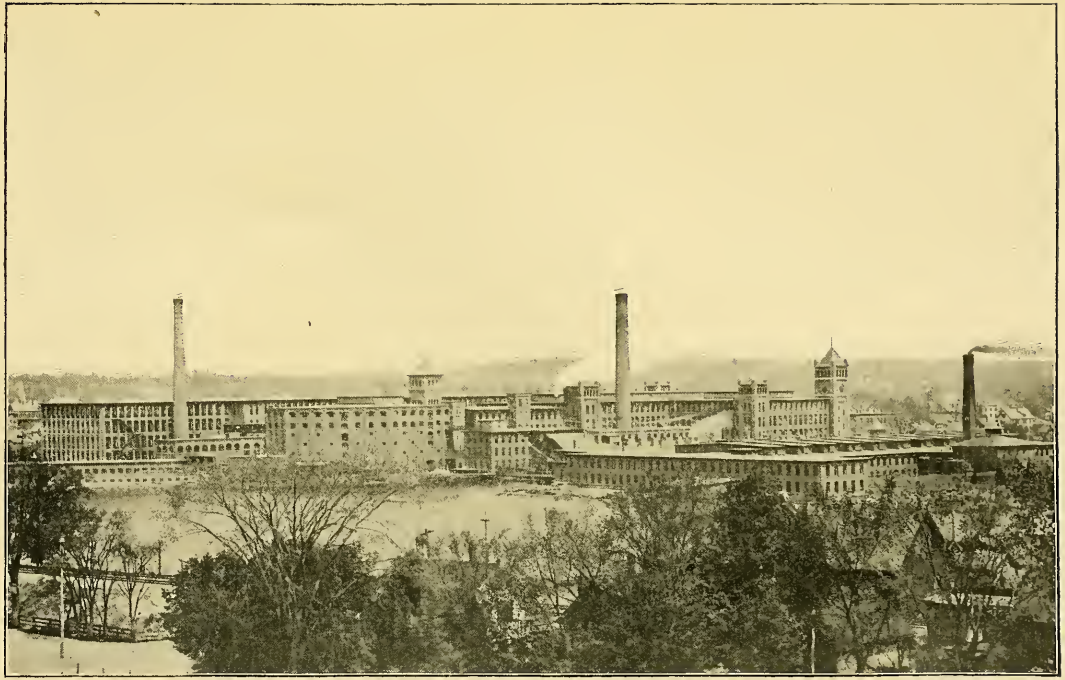
SPECIALIZATION OF THE WORSTED INDUSTRY

fully, as experience shall gradually establish, here as in nature, the Darwinian law of the survival of the fittest.

There could not well be a greater industrial contrast than that presented by the development of the worsted manufacture here, and that which has taken place in Europe. The one experience may be called the reverse of the other, and it is necessary to the purposes of this narrative to show how and why this is so.

Origin of the American woolen mill

Our earliest woolen mills were evolutions from the carding mill and fulling mill of colonial days. They were located upon some stream, and were situated at long distances from each other. When power machinery was introduced, and factory-made cloth began to supersede the "homespun" of the fireside with which our ancestors clothed themselves, the pioneer manufacturers found it necessary to perform all the processes connected with the making of cloth. They must not only spin their own yarns, but they must dye and finish their own cloths, there being nobody in the neighborhood who could do any of these things for them. Every woolen mill was compelled to be a complete entity in itself; and thus by sheer force of circumstances, our method of manufacturing developed and continued along its own individual lines. It is only within a comparatively



WORSTED DEPARTMENT OF THE ARLINGTON MILLS

few years that the inertia of inherited habit has begun to give way, here and there, before the superior advantages of a subdivision of the industry into its several specialties. This modern tendency to specialization is quite as marked in the other great industries, like cotton and iron and steel, as in the worsted manufacture. We have recently seen it carried to its logical development in the manufacture of bicycles, the several parts of which are now made, as a rule, in separate and independent establishments.

SPECIALIZATION OF THE WORSTED INDUSTRY

This tendency to specialization, so comparatively new in the United States, was its earliest characteristic in England. The minute subdivision of the industry in Great Britain is an evolution of centuries, and a survival of the days of hand manufacture, under which, just as at present, the spinner, the weaver, the dyer, and the fuller had each his distinct, well-defined field of work, into which the rules of the guilds forbade either of the others to encroach. It was a subdivision unaccompanied by any inconvenience, because of the close concentration of the cloth manufacture in particular localities. There were certain towns where practically the only occupation of the people was some one of those connected with the cloth manufacture. As machine manufacture gradually drove out

Origin of the industry in England

SPECIALIZATION OF THE WORSTED INDUSTRY

the hand worker, this differentiation continued along lines established by immemorial custom, and there are but slight departures from it in England to-day, because experience leads men to believe that on the whole it is the most efficient and economical system of manufacturing.

The extent to which this specialization of the worsted manufacture is carried abroad may not be fully realized by those Americans who are not in the habit of making frequent trips across the water. It will facilitate the purpose of this narrative to indicate its character and its advantages somewhat in detail.

Top making in England

The manufacture of tops is its starting-point. Comparatively few of the English and continental spinners and weavers make their own tops. While this separate top manufacture is a survival of the old days of hand combing and domestic industry, yet the reason why it has survived is because experience has abundantly proved that it is the most satisfactory and economical method of manufacturing. Hence it happens that the enormous quantity of wool which is annually woven into worsted goods in England passes originally through a comparatively small number of combing establishments. There are in Yorkshire, all told, according to Morrell's Textile Directory, only about sixty combing establishments, which comb wool for

hundreds of manufacturers. A few of these establishments are of enormous size; the firm of Isaac Holden & Sons owns two complete combing plants in Bradford and two others of equal size on the continent, one at Rheims and one at Croix, near Roubaix, in France. It is stated in the Report of the Royal British Commission on Technical Education (Second Report, vol. 1, page 259) that two fifths of all the colonial wool annually sold at the London auctions passes through the combing machines operated by this firm. The statement seems incredible when we consider how enormous is the volume of this wool. In questioning it, we do not wish to seem to detract from the prestige of this great firm. Of that there can be no question. Sir Isaac Holden, M. P., the recent head of the firm, was the inventor of the combing machine which bears his name, and which, in conjunction with the Heilman, Lister, and Noble machines, has done more than any other invention to promote the wool manufacture and develop the wool-growing resources of the southern hemisphere.[1] It is an impressive thought that, but for the invention of the comb, the enormous increase in the world's wool supply

SPECIALIZATION OF THE WORSTED INDUSTRY

The Holden combing mills

Results of the combing machine invention

[1] The increase in the wool clip of Australasia, South America, and the Cape Colonies has been from 154,000,000 pounds in 1860 to 1,100,000,000 pounds in 1896, an increase of over 600 per cent.

SPECIALIZATION OF THE WORSTED INDUSTRY

which marks the last forty years could not have taken place.

The reason why the Bradford manufacturers send their wool to the Holdens and others to be combed is because they can get the work done better and cheaper than they can do it themselves. That holds to reason; if it were not the fact, these shrewd Yorkshiremen would have found it out long ago, and would now be making their own tops. If it were not the fact, the rapid development of the Antwerp top market would have been an impossibility.

This top market, like that at Roubaix in France, is a peculiar outcome of peculiar conditions, and has much disturbed the staid Englishmen, with their conservative methods of doing business. The Bradford "Observer" describes these terminal top markets at Antwerp and Roubaix as "gigantic gambling establishments, which have become the Monte Carlo and Monaco of the top trade." The origin of these top markets is attributed to the early attention which the Belgians and the French gave to the burry and ill-conditioned wools of South America. They devoted special attention both to machinery for removing the burr, and to chemical methods of treating it. In the earlier days of the sheep industry of Argentina, the wools of that country were shunned by English

The Antwerp top market

manufacturers on account of their burry condition, and, finding their way across the channel, were sold at auction for what they would bring, — almost given away, in comparison with the prices paid for Australian wools. The Belgians experimented with these defective wools, and, hitting upon various expedients for getting rid of the burr, they were enabled to make yarns very much cheaper for the quality than any offered by English or Scotch spinners. This yarn found its way to England and elsewhere, and none made from other wools could compete with it in price. English, French, and German spinners were driven to seek the tops from which it was made; an enormous business grew up; and as these "B. A." tops were practically all of one quality, prepared to spin to a single number, and as they were offered in constantly increasing quantities, the development and advance of the terminal top markets were so rapid as almost to approach a phenomenon. It was contended, in their favor, that in the presence of vastly accelerated means of communication and transport, the operator should have correspondingly increased facilities for turning over his ventures; and that it would be a great advantage to the spinner, weaver, etc., to be able to cover, by dealings in "futures," losses which might arise from subsequent fluctuations of the market.

SPECIALIZATION OF THE WORSTED INDUSTRY

"Futures" in tops

SPECIALIZATION OF THE WORSTED INDUSTRY

The result has been very like that which occurs from the sale of "futures" in cotton, corn, and wheat. The circular of Buxton & Ronald for 1896 states that from November, 1894, to October 31, 1895, the transactions in River Plate tops of the recognized standard type at Antwerp and Roubaix were *twelve times greater* than the quantity actually produced during the same period.

Uniformity

The development of the Antwerp top market is a recognition of the fact that the top is the earliest stage at which wool can be traded in, as corn or cotton are traded in, with any certainty of uniformity in the article. As a matter of fact, the Antwerp tops necessarily vary materially in quality; for all combers are not equally careful, either in their processes of manufacture or in the purchase and sorting of their stock. The manufacturer who resorts to Antwerp for tops necessarily enters a lottery, a risk which will be wholly escaped by the American manufacturer who buys the Arlington Mills tops, for reasons that we shall presently see.

How the new enterprise originated

The management of the Arlington Mills was first brought to the investigation of the foreign methods of specialization in the summer of 1894, when legislation was pending to remove the duty upon foreign wool, and otherwise so to change the status of the manufacture as to amount to

A VERMONT MERINO RAM

an economic revolution. It appeared necessary to prepare to adapt American methods to new conditions; and the treasurer of the Arlington Mills visited Europe during the summer in question and acquired all the information possible upon the system of manufacturing there prevailing. He became convinced that to secure the best possible results in this country, radical changes were necessary, beginning at the very foundation. It was made clear to him that the most successful combed wool manufacturers abroad depended primarily upon the cheapness and perfection with which their wool tops were produced; and also that this cheapness and perfection combined were only possible when the manufacture was specialized on a large scale. For such a specialization, it was evident that certain things were imperative: —

SPECIALIZATION OF THE WORSTED INDUSTRY

First. Knowledge of the wools of the world and how to mix or assemble them.

Requirements for success

Second. Facilities for purchasing such wools at minimum cost in the chief countries of production or sale.

Third. Buildings especially adapted, both as to arrangement and mechanical appliances, for the economical handling and distribution of wool in bulk.

Fourth. The very best machinery, especially adapted to the various kinds of wool to be

worked, so as to secure a maximum of production at a minimum of expenditure for labor and loss from waste.

Fifth. A home market for wool tops.

Four of these five requirements were attainable, the doubtful one being the fifth; was it possible to secure a home market for tops? Did it involve too radical a change in our American methods of manufacture, to promise a success quick enough and large enough to warrant the establishment of an enterprise for top making on a large scale?

The market tested

The way to test the question was to begin the business with such machinery as the mills already possessed. Prior to this time, certain portions of the carding and combing machinery had been run night and day, and it was decided, if purchasers for the tops could be found, to run the whole of this machinery night and day. This was done during a small portion of the year 1894, and practically during the whole of the year 1895, purchasers being found at satisfactory prices and for considerable quantities, for all the tops it was possible to produce in excess of the Arlington Mills' own wants. This success seemed to fully warrant the undertaking of the enterprise described in these pages.

It was further justified by the previous experience of the Arlington Mills in the manufac-

ture of worsted yarns for sale. This corporation was among the first New England mills to undertake the manufacture of worsted yarns for sale on a large scale, although the manufacture had been carried on in Philadelphia for many years. In that city, where they have a compact network of manufacturing establishments, all within hailing distance of each other, the specialization or differentiation of the wool manufacture, its division into distinct and separate groups, such as spinning, weaving, and finishing, which distinguish it abroad, had been making headway for many years before it began to appear at all in New England, showing, in a manner instructive to the student of economic conditions, how much local environment has to do with determining the special development of industries.

SPECIALIZATION OF THE WORSTED INDUSTRY

The experience of the Arlington Mills in the manufacture of worsted yarns for sale had proved that the industry was already in a state sufficiently advanced to permit of further development along the line of the least resistance, to borrow a phrase from the scientist. When the manufacturer could make worsted goods without incurring the added expense of all the machinery for making the yarns, it followed that the manufacture must grow, not only faster but more safely; for it was at once placed upon

The manufacture of yarns for sale

SPECIALIZATION OF THE WORSTED INDUSTRY

a healthier basis, from an economic point of view. To-day the manufacture of worsted yarns for sale employs all the energies of a number of mills; the business is growing and will continue to grow, for the method permits of more economical and, on the whole, more satisfactory manufacturing.

Advantages of the method

The smaller user of worsted yarns can buy them cheaper than he can make them. He buys only such yarns, in the first place, as exactly meet his requirements. If he is making his own yarns, he must use good, bad, and indifferent, just as they come from the frames. It is not difficult to understand why the manufacturer who spins a comparatively small quantity of yarn cannot obtain as uniformly good results as the manufacturer engaged in making millions of pounds. In the first place, he cannot buy his stock to such good advantage; and therefore he cannot obtain such perfect uniformity in his sorts. In the second place, where the spinning done is large in amount, the expert supervision is of a higher grade and the attention to every detail necessary to perfect work is closer and more exacting. All yarns made for sale must conform to a fixed standard. That standard it is cheaper and easier to buy, under certain conditions, than to maintain for one's self.

All that is true of yarns, in these respects, is equally true of the tops from which the yarns are made. Whatever advantage accrues to the weaver, from the ability to buy yarns suited to his special needs, will accrue equally to the spinner from the opportunity to buy tops.

The same with tops as with yarns

Thus one development leads logically and naturally up to another. Every advance in one direction is sure to inaugurate other advances in a great variety of other directions. Once the specialization of a great industry has fairly started, its further progress is certain, even though it may be gradual.

The construction of an American top mill, under the manufacturing conditions above described, compelling the investment of a large amount of capital, in anticipation of the development of a business still in embryo, so to speak, may at first sight appear to involve a large element of chance and uncertainty. For that reason it may be worth while to enter somewhat at length, in this connection, into the reasons which lead to the conviction, on the part of the Arlington Mills' management, that the top business, the foundations of which are already laid, is sure to develop, and needs only the stimulus of such a plant as it has constructed to develop rapidly. That it is an instance in which

"increase of appetite had grown
By what it fed on,"

is not only shown by the experience of the Arlington Mills during the past three years, in constantly being called upon to supply tops and rovings to other mills, although not equipped to that end or in the market with that class of goods, but also by the statistics of importations under the recent tariff.

Prior to the enactment of the tariff act of 1894, the duty on tops and rovings, being the same as that imposed upon the finished goods, was prohibitory, or high enough to be so regarded, in the absence of any demand for them.

Imports of foreign tops

Up to 1894, practically no worsted tops had ever been imported into the United States. By the law of that year, not only was the specific duty wholly removed from tops, in consequence of the removal of all duty from wool, but the ad valorem duty was reduced to twenty per cent. Almost immediately there sprang up a considerable importation of tops and rovings, which reached, in the first year under the new law, a total of 1,567,372 pounds; in the second year a total of 1,147,461 pounds; and in the third year, that ending June 30, 1897, a total of 5,662,952 pounds, having a foreign value of $1,821,405.

This great importation of the last year was of course largely anticipatory of the enactment of the new tariff; but it was conclusive evidence that there is a market for the commodity, which only requires a supply. That this supply cannot hereafter be obtained from abroad is evident to those familiar with the peculiar construction of the tariff act of July 24, 1897. This act provides (par. 364) that "Wool and hair which have been advanced in any manner or by any process of manufacture beyond the washed or scoured condition, not specially provided for in this act, shall be subject to the same duties as are imposed upon manufactures of wool not specially provided for in this act." Tops, rovings and ropings, the semi-manufactured products of wool, are all included in this classification. It is plain that Congress, in fixing these rates of duty, was governed by the desire to encourage in this country not simply the manufacture of the finished articles, but also of the semi-manufactured products out of which they are made. The Arlington top mill was planned at a time when nobody dreamed of a tariff act like that of 1897; it was practically completed before that act was framed; and it is fortunately in a position to supply, from a domestic source, a demand which can hardly be supplied hereafter from abroad.

SPECIALIZATION OF THE WORSTED INDUSTRY

The new tariff on tops

SPECIALIZATION OF THE WORSTED INDUSTRY

It is evident, then, that there is a demand for tops in the United States, a demand which is due to the operation of the causes we have been enumerating. In taking the step which will supply this developing demand from a domestic source, the Arlington Mills is rendering possible a much more rapid advancement of the worsted manufacture in the immediate future. We will point out one reason in particular why this must be so. Undoubtedly the cause of the relatively slow development of the worsted manufacture in the United States has been the exceptionally large capital required in the way of plant. It has been necessary to equip a mill from the start of the wool to the finish of the goods. The machinery required in the preparatory processes of the manufacture of worsted yarn is costly and elaborate, compelling a much larger outlay of capital than the preparatory machinery of the woolen manufacture.

Less capital required to manufacture

It has been estimated that three fifths of the total cost of a worsted spinning plant is incurred for machinery necessary to processes which are prior to the spinning frame itself, *i. e.*, to the making of the top. Once the top is made, it is comparatively easy and inexpensive to draw and spin it into yarn. A comparatively small amount of capital will therefore equip a spinning mill, where the necessity is removed for making the

top. It may be fairly anticipated, therefore, when the opportunity is thus opened, that such spinning plants will spring up ; and that as they increase in number there will be a corresponding increase in the number of weaving plants, depending upon spinners to supply all the yarns that may be required.

SPECIALIZATION OF THE WORSTED INDUSTRY

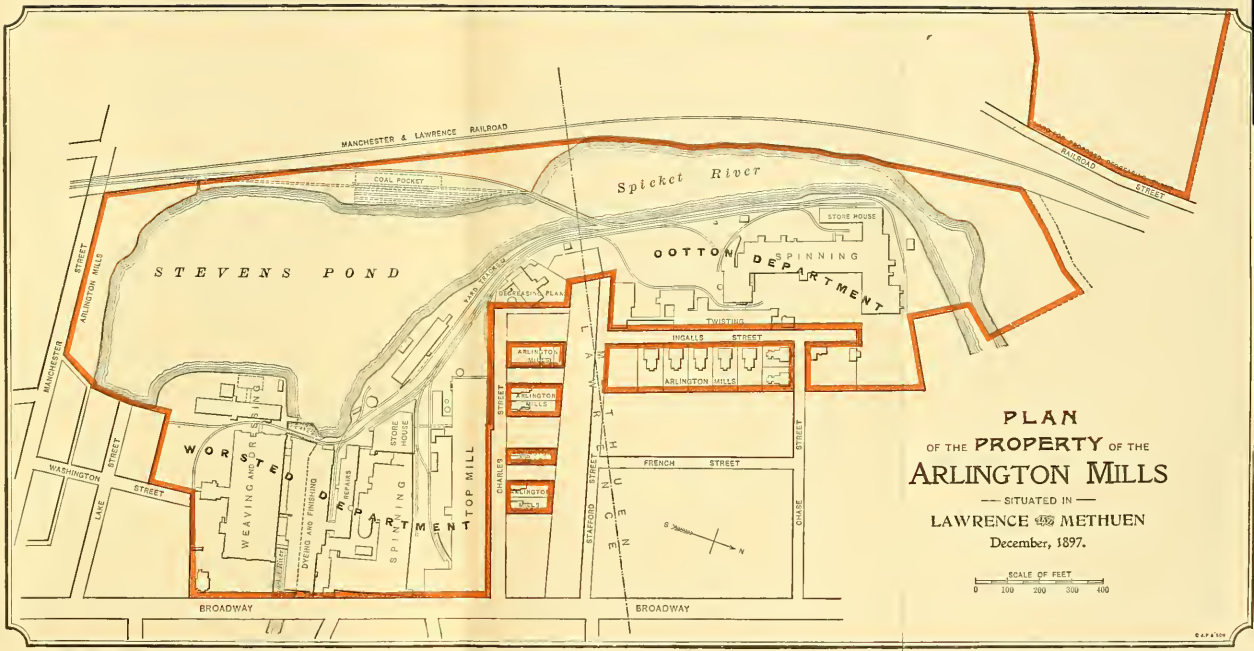
An increase of spinning mills

It is in this way that the foreign manufacturer has largely obtained his advantage over our own. Yorkshire is full of comparatively small establishments, engaged exclusively in the business either of spinning or of weaving. Many of the colossal fortunes made in the textile industries of England began in this humble fashion. Having received an order for a certain kind and quantity of yarn, the spinner has only to go upon the market and purchase the necessary amount of tops to fill his order. He is able to pay the top maker's profit out of his saving of interest upon a large investment in plant and a long holding of his raw materials. The capital needed is not only much smaller, but it can be turned over much more rapidly. The lack of similar facilities, due to minute specialization, has been a distinct handicap to the progress of the worsted manufacture in this country.

Having thus described the general plan of this new departure, the reasons which have justified it, and the advantages that must spring from it,

SPECIALIZATION OF THE WORSTED INDUSTRY

we proceed to a detailed description of the new buildings which have been constructed at Lawrence for the purpose of carrying it on, of the new machinery installed, and of some of the new methods and processes of manufacture which have been adopted, after long and careful experiments, to secure the best possible results.



PLAN

OF THE **PROPERTY** OF THE

ARLINGTON MILLS

— SITUATED IN —

LAWRENCE & METHUEN

December, 1897.

SCALE OF FEET

0 100 200 300 400

LADIES SPINNING AND WEAVING
(From a Fifteenth Century MS. in British Museum)

CHAPTER III

DESCRIPTION OF THE NEW TOP MILL

IF the reader will glance at the ground plan of the Arlington Mills given herewith, he can obtain at a glance a general idea of the relation of the new top mill, Location of the new mill

DESCRIPTION OF THE NEW TOP MILL

both as to size and location, to the older portions of the plant. The new spinning mill erected in 1891 abuts the corner of Broadway and what was then known as Chalmers street. Subsequent to the erection of the spinning mill, the corporation added to its property north of Chalmers street, and the city government of Lawrence, in view of the plan to erect a new top mill on this property, closed Chalmers street as a public highway, the fee in which already belonged to the corporation, and granted the Arlington Mills the exclusive right to its use, since it led nowhere except into the mill property. What was Chalmers street is therefore now the broad passageway separating the top mill from the spinning mill.

Size

The new structure is one of the largest mill buildings in the United States. Its actual dimensions are 677 feet 7 inches in length by 109 feet 8 inches in width, over all, outside, with a wing 88 feet 8 inches long by 78 feet 5 inches wide inside. The wing is two stories with basement, and the main building four stories with basement.

The main building.

This main building is divided at the engine-room by a belt race ten feet wide, inclosed by brick walls running up to the third story above the basement, making divisions of the basement and first and second stories into two rooms each at this point. The first story front room, 528 feet

long inside, is the combing-room. The room in the rear of this, 128 feet long and 101 feet wide, inside, and the basement room under it (the wash-room proper) are devoted to the handling and washing of the wool. DESCRIPTION OF THE NEW TOP MILL

The carding floor (the second story), though divided into two rooms of the same dimensions as those on the floor below, is so constructed as to constitute practically one great room.

The third floor is the storage-room, divided by one partition wall instead of two, so that the dimensions are respectively 528 feet long by 101 feet wide and 139 feet 4 inches long by 101 feet wide.

The entire fourth floor is the new sorting-room, and its division and dimensions are the same as those of the storage floor. The sorting benches are so arranged around this top floor as to give under ordinary circumstances one window bay to each sorter, the room accommodating, in this way, 155 wool sorters. But by placing an additional double row of benches down the middle of the room, the number of sorters can be doubled, still leaving ample elbow room for each sorter. The sorting-room

The arrangement of these several floors has been carefully studied, with a view to the utmost economy of time and labor in the handling of the material at the several stages of manufac- Arrangement of the building

DESCRIPTION OF THE NEW TOP MILL

ture. The progress of the wool from the time when it has been delivered from the cars, in the bale, to the sorting-room at the top of the building, is downward, from floor to floor, until the finished top reaches the basement, where it remains for storage, unless it is to go into immediate use. Nearly the whole of this basement, except the wash-room, is devoted to the storage of the completed tops. It has been carefully constructed, so as to secure the proper temperature in all weathers. It has a storage capacity of a million and a half pounds of top. This basement connects directly with a large wing on the south side of the building, which contains the shipping department and connects directly with the railroad tracks of the Boston and Maine railroad. In this wing are located also the offices for the clerical force of this department of the mill, and also those of the overseer and his clerks.

Heat and ventilation

The ventilation of this building is provided for by means of drosophore fan intakes, which supply both moisture and fresh air at the same time. The temperature of the air can be somewhat regulated, according to the season, by using cold water or warm water. It is calculated that any additional heat will not be required either on the combing floor or the card-room floor, beyond that which is supplied in

the necessary heating of the machinery itself. The upper floor, containing the sorting-room, is heated by a hot air system. The building is so arranged that the ventilation of the lower rooms may serve to keep the storage-room sufficiently warm. All the arrangements for heating and ventilating the building have been constructed in accordance with the latest scientific plans.

The building is equipped with drosophores, which permit the regulation of the humidity of the atmosphere, to meet the most exact requirements of perfect manufacturing.

Stairways

The main stairway of the building is situated very near the centre, and is arranged on the double flight plan, that is to say, one flight on each side with a wide middle stairway. Experience has shown that this arrangement is the most advantageous to assist in rapid exit.

Two other stairways facilitate connection between the several stories. One of them is at the northeast corner, within an interior tower, so as to be used as a fire escape. The other stairway tower is at the southwest corner, next to the engine-room. It will also serve as a fire escape, and contains, in addition, a hydraulic elevator, connecting all the floors from the basement to the sorting-room. These towers also contain the retiring-rooms for the employees.

Elevators

A second hydraulic elevator runs between the

DESCRIPTION OF THE NEW TOP MILL

walls of the belt race which intersects the building near the centre. This elevator affords quick connection between the wash-house, the carding-room, and the combing-room. A third elevator runs between the basement and the first floor of the shipping-room wing. This elevator is also connected with the combing-room and the basement under the main building, and with each floor above.

Engine and boilers

The boiler-house and engine-room comprise another one-story wing of the building located on the same side as the shipping wing. The chimney is 175 feet high and has a six-foot inside core. In the engine-room is a compound condensing Corliss engine of about 1200 horse power.

The boilers are of the water tube type, in three banks of two boilers each. They are also fitted with stokers and automatic coal supply, so arranged that one man can take care of the entire boiler-house, including the removal of the ashes, and not be hard pushed at that. These modern facilities for the saving of labor in boiler-rooms are among the most interesting signs of the rapid mechanical advance of recent years, although they are not more striking, perhaps, than those which appear throughout the whole mechanical outfit of this new top mill.

Labor-saving facilities

From the preceding description of the build-

THE NEW TOP MILL

ing containing the top-making equipment, the reader will readily infer that it is proposed to make this new plant an organism complete in itself, and entirely distinct and separate from the long-established business of the Arlington Mills. The top mill has no mechanical connection with the rest of the plant. It not only has its own power to move all its machinery, but it has its own set of books and bookkeepers, and all its accounts will be separately kept.

DESCRIPTION OF THE NEW TOP MILL

A complete organism

Having described the building, we can now intelligently follow the progress of the material from room to room, and process to process. The raw material, on reaching the mills, is carried directly from the cars to the upper story, where it is sorted. The sorts which are to be delivered for degreasing to the solvent process plant, described in the next chapter, are dropped directly from the sorting-room floor into cars or large trucks, which are run into the building to receive them, on the first floor, in the department above the wash-house. The wool is dropped by means of galvanized iron chutes, which run to the third or sort storage floor, so that the material can be taken with equal ease from either the sorting-room or storage-room. These trucks are delivered to the solvent process plant by an electric motor system. They are so adjusted as to dimensions that they

Handling the material

DESCRIPTION OF THE NEW TOP MILL

can be elevated to the top floor of the solvent process building, run alongside the kiers, and emptied, practically without handling.

The wool having been degreased, the kiers are so arranged that they empty their contents directly back into the trucks. By the electric motor system, they are thence brought back to the top mill, where they are carried into the first floor, directly above the wash-house, where they are unloaded, ready for delivery into the feeders of the washers below. From the wash-room, the material passes to the card-room on the second floor above. Having been carded, the card balls are dropped by means of chutes to the first or combing-room floor. Thence the progress is steadily forward, without direct handling, from one series of machines to the next series, passing from the gilling-machines to the combing-machines, and thence to the balling-machines, without once being placed in a truck. After being balled on the finishing boxes into top, the material is dropped from this combing-room floor through chutes, into trucks, which await it in the basement, and which carry the different grades and lots of tops to their appropriate location in the storage-room, where it is finally placed in bins. It should be added that this storage basement is connected through the shipping-room basement, by means of a tunnel,

The storage of tops

with the basement of the spinning department, which will buy its top from the top mill just as other customers do.

DESCRIPTION OF THE NEW TOP MILL

It is calculated that there can be delivered from this building, with these improved expediting processes, 300,000 pounds of top a week, requiring for their production between 600,000 and 800,000 pounds of greasy wool per week. The top mill is thus capable of consuming the entire wool clip of the States of Ohio and California, which, next to Texas, are the two largest wool-growing States of the Union. The fleeces of 20,000 sheep will pass through its machinery every day that it is in full operation. Its capacity is equal to one eighth of the total wool clip of the United States.

Capacity of the mill

EGYPTIANS PREPARING FLAX
(From a Theban frieze)

CHAPTER IV

THE SOLVENT PROCESS FOR CLEANSING WOOL

Defects of previous methods of wool cleansing

IN describing the new methods adopted at the Arlington Mills to insure perfection of product, we begin naturally with the cleansing of the wool, which is the first point in the manufacture. It is at this initial stage that the most valuable of all recent improvements in the handling of the fibre is to be applied at Lawrence.

Up to the time when the naphtha process of cleansing wool was first successfully undertaken at the Arlington Mills, about three years ago, this operation remained the most defective point in the whole process of the manipulation of wool. This was the more extraordinary, not simply

because it is the initial step, but because it is the step upon which depends the success of every subsequent process. If the wool is injured in the cleansing, or if it is only partially cleansed, if its fibre is impaired by contact with too powerful alkalies, or by immersion in overheated scouring solutions, the harm done is visible at every subsequent stage, not merely in its effects upon the working qualities of the wool, but in the "feel," appearance, and durability of the goods produced from it. Poorly scoured wool resists the action of mordants, and takes on a "streaky" color, because the dyes cannot properly penetrate the fibre. Many an unsuccessful wool manufacturer can trace his troubles straight to the scouring-room; many do trace them there, only to find themselves confronted by a problem which they are helpless to solve.

THE SOLVENT PROCESS

Of course, there are many excellent scouring machines in existence, and there have been great improvements made in recent years. The difficulty has not been altogether with the machines, but with the agencies used in connection with the machines, to cleanse the wool in its passage through them. Potash, carbonate of soda, silicate of soda, ammonia, and soap are all more or less used in wool washing. In the old days urine was a common agency used in the household manufacture, and was a better material, so

Agencies for wool scouring

THE SOLVENT PROCESS

far as its effects on the wool were concerned, than many of the modern substitutes. To-day soaps are the scouring agents most generally employed; and the results necessarily depend very largely upon the quality of the soap used. This is one of the many difficulties in the way of successful scouring, for perfectly satisfactory soap is hard to find.

It follows that the scientists who study wool have for years devoted much labor and investigation to efforts to discover some new and really scientific process for scouring wool. Many a man has thought himself on the point of fame and fortune, only to be bitterly disappointed, when his discovery was subjected to actual test.

A difficult problem

Wool is so different in its characteristics from every other product of nature, that one must understand it just as a mother understands her child, in order to deal with it successfully at the stage when it requires the most delicate handling, that is, while it is passing from the greasy to the scoured condition. As a matter of fact, the old-fashioned way of cleansing it — the use of a given amount of potash and soap and water at a given temperature — has never yet in general practice been superseded. In the old days, they used to scour it in tubs, very much as clothes were washed. With the introduction of modern machines for cleansing large quantities rapidly,

the difficulties in the way of perfect results have become more manifest. Those difficulties arise from the impossibility of always maintaining the same conditions, as to the heat of the water and the strength of the alkali. Dr. F. H. Bowman, the English expert in wool, has written that his own experience has shown him that in a bowl of water and wool, the temperature of the water in some parts may almost approach the boiling point, 212 degrees F., while in other parts of the same bowl it may not be more than 90 degrees F., or even less. The best results are impossible under such uneven conditions. The mere felting effect of a soap bath is sufficient to cause material detriment to the proper condition of the staple for after handling. THE SOLVENT PROCESS

Theoretically, the most perfect condition in which the fleece of the wool could be delivered to the card would be precisely the condition in which it is grown, without any disturbance beyond the separation of one lock from another, and in addition total freedom from dirt and grease. This can only be done approximately under the best of circumstances, and as a rule the approximation is very far indeed from perfection.

The problem is made the more complex by the number of different elements to be dealt with. Chevreul's analysis of a particular sam- Constituents of wool

ple of merino wool showed its constituents in the greasy state to be as follows:—

Earthy substances	26.06
Suint or yolk	32.74
Fatty matter	8.57
Earthy matter fixed by grease	1.40
Clean wool	31.23
	100.00

The problem of dealing with these different substances presents two distinct phases; and the defects of all previous systems of cleansing wool have grown out of the fact that they have undertaken to remove both varieties of substances, the dirt proper and the yolk and fatty matter, by one and the same process, and the wool has necessarily suffered in consequence.

Two processes in one

The advantage of the new process adopted at the Arlington Mills lies primarily in the fact that it is two separate processes. The grease is first extracted from the wool, leaving behind in the wool, besides the earth and dirt which naturally accumulate, an abundance of natural potash soap, by which it is easily washed, — once the grease is removed, — without the addition of any other soap or alkalies, in a water heated only to a very low temperature.

The consequence is that under the new process the wool comes from the ordinary scouring machine, after having first passed through the

naphtha process, in a light, fluffy, "lofty" condition, which greatly facilitates its manufacture at every subsequent stage. The contrast is not unlike that between a batch of bread which rises perfectly, under the operation of the yeast, and another batch which for some scientific reason does not rise at all.

Naphtha and bi-sulphide of carbon

Chemists have long been familiar with the fact that the grease of wool can be entirely removed from the fibre by the use of some solvent material, such as petroleum ether (naphtha), or bi-sulphide of carbon. Endless experiments have been made with these substances, in search of a practical method of utilizing them for this purpose. These experiments always demonstrated that the use of such a solvent left the wool in a superior condition; but no method of practically applying them was devised until that now in operation at the Arlington Mills was perfected.

Holden's experiments

Some years ago the late Sir Isaac Holden, the Bradford wool comber, experimented with bi-sulphide of carbon on a practical scale, and at a large expenditure. The results were entirely satisfactory, so far as the wool itself was concerned; but no practical method of application was devised which obviated the very great danger in the handling of so combustible a material. Several explosions occurred, by which

THE SOLVENT PROCESS

two or three persons lost their lives; and these accidents finally led the borough of Bradford to pass an ordinance forbidding any further use of the process within its limits. So far as we are informed, no English manufacturer has ventured to take up the experiments at the point where Sir Isaac Holden abandoned them. But similar experiments, both with naphtha and bi-sulphide of carbon, have been frequent in France and Germany; and in the United States the practical application of the solvent process has been several times attempted, notably at Pompton, New Jersey, only to be subsequently abandoned on account of the inherent difficulties of the problem. It is satisfactory to American pride that the practical achievement of this great problem, over which the brightest scientists of Europe have so long been at work, should have been accomplished on American soil.

Mrs. Richards' experiments

Some time prior to any of the experiments named above, the very great advantages of this method of cleansing wool were demonstrated by Mrs. Ellen H. Richards, professor of chemistry in the Massachusetts Institute of Technology, at Boston. In the Bulletin of the National Association of Wool Manufacturers for March, 1879, appears a letter from Mrs. Richards, in which she details the results of some experiments she

THE ANGORA GOAT (FROM WHICH MOHAIR IS OBTAINED)
ASIA MINOR

had been making with the natural oil, grease, or suint of sheep's wool. Mrs. Richards was impressed by the fact that here was a valuable by-product of wool which went absolutely to waste in this country, notwithstanding that it was carefully saved in France and other wool manufacturing countries, and much of it imported into the United States under the name of degras, for the use of curriers and for many other purposes. THE SOLVENT PROCESS

In studying how this by-product of wool might be saved to economical advantage, Mrs. Richards found that bi-sulphide of carbon had been used to some extent in France, but with unsatisfactory results, not only on account of the heat required to volatilize the solvent and the consequent danger of explosion, but also because of the high cost of the bi-sulphide of carbon. She accordingly turned her attention to naphtha, and quickly discovered that it was a solvent in many respects superior to the other. Indeed, she learned that there were already several patented processes for the use of benzine for the extraction of wool grease, none of which, she convinced herself, had any practical value. But she became satisfied that by the use of a higher quality of naphtha, of about 86 degrees, the results desired could be admirably accomplished. As a matter of historical inter- Naphtha as a solvent

THE SOLVENT PROCESS

est, we quote here her account of the method of procedure she adopted:—

"We packed the wool in a closed vessel, and allowed the naphtha to remain in contact with it for about twenty minutes without any application of heat. The liquid was then drawn off and fresh naphtha run in; the process being repeated two or three times, according to the amount of grease in the wool. 'Gasoline' of this quality boils at 90° to 100° F., and air of 50° or 60° F. completely removes it. The naphtha has no affinity for water, and does not, in this cold liquid form, carry away any moisture; very little will be taken out by air of 60° F. before the naphtha is all gone. In the large way, a current of warm air would now be passed through to carry off the absorbed liquid; in our experiments we simply exposed the drained wool to the out-door air for a few hours. The wool is picked and beaten (the dust being saved), then put into warm water and washed without the aid of any other substance than the soap of potash which is left on the fibre, untouched by the naphtha. The wool thus obtained is very white and soft, and has a 'crinkly' appearance."

Gains from the naphtha process

Mrs. Richards proceeded to state some of the advantages which she observed, as the result of this method of extracting the grease; she named "the more perfect cleansing of the wool, the

better condition of the fibre for taking dyes, the ready recovery of the waste product, and the prevention of the furthur pollution of streams from wool-washing establishments." The only disadvantage she would admit was "the inflammable character of the naphtha, rendering a separate building necessary." She added that "this is not an insuperable obstacle, as the use of the substance for several industries has been perfectly successful."

Time has vindicated Mrs. Richards' judgment in this respect. The solvent process has now been in operation at the Arlington Mills long enough to completely demonstrate its success in the two essential particulars: It produces better results with the wool than any other cleansing process that has ever been applied; and it can be utilized, on a large scale, under the proper mechanical conditions, without any danger whatever to the establishment or to those employed in it.

Mr. Maertens' experiments

The history of the introduction of the solvent process is briefly as follows: Some time previous to the operation of the plant at Pompton, N. J., already alluded to, Mr. Emile Maertens, of Providence, undertook, at the suggestion of the Arlington Mills, to devise a solution of the mechanical and chemical difficulties to which allusion has been made. After a protracted

series of experiments, he finally drew up plans and specifications, which were studied, amended, and more or less tested, and finally an agreement was concluded with Mr. Maertens, for the introduction of the system in the Arlington Mills. By the spring of 1895, the experimental plant was sufficiently completed to permit of final tests on a large scale. In this plant, tests were made with about 100,000 pounds of wool; and the results were so far beyond even the most sanguine expectations, that there was no longer any hesitation about erecting the expensive plant which is now in operation. It is located at a distance from the other buildings, and constructed with every safeguard that human ingenuity can devise, for the safety and comfort of those who operate it.

Description of the new solvent plant

The building, which is a wood frame, iron-covered, sits in a copper tank of sufficient depth to hold all the thousands of gallons of naphtha carried in the reservoirs, should any accident discharge the latter, thus insuring against the escape of any naphtha into the sewers, streams, or adjoining premises. All the pipes, tanks, digesters, stills, etc., are electrically connected with this copper tank, as is each of the iron plates which cover the building. The copper tank is in turn electrically connected with the neighboring river and the railroad track, thus

rendering the whole structure and its contents lightning proof. A large gas holder outside of the building is filled with an inert gas, or a gas which does not form an explosive mixture with naphtha vapors or with atmospheric air, which does not support combustion, but on the contrary has the property of extinguishing fire. This gas is compressed and used as the motive power to move the naphtha through the digesters, tanks, etc., no liquid being pumped whatever. This gas is also used as an atmosphere in which to carry on the degreasing operation and to replace in the naphtha tanks any liquid being withdrawn therefrom, so that at all times the naphtha is protected by an atmosphere of a fire-extinguishing gas. When the gas has done its work, or when it is driven out of the digesters, tanks, etc., by incoming naphtha, it is automatically returned to the gas holder (to be re-used) by way of a trap tank, which acts as a water seal and safety valve between the system and the gas holder. This method, besides insuring against the possibilities of an explosion, prevents the loss or escape of any gas or naphtha vapors into the atmosphere. Although many thousands of gallons of naphtha are in motion all the time, there is not the slightest smell to indicate its presence upon the premises, the degreasing operation being carried on in a closed circuit

The process described

and under seal, and everything being absolutely tight. Practically all of the solvent used in the operation is recovered.

Condition in which it leaves the raw material

The wool having been stripped of its grease by the solvent process, it emerges from the kiers or digesters in a perfect condition, without the vestige of a smell of naphtha about it. It is carried at once to ordinary machines, through which it is passed, in tepid water only, and whence it issues in a condition absolutely clean and sweet, brilliantly white, and in workable condition that is perfect. The use of the washing machines, under these conditions, requires the minimum mechanical action upon the fibre. No unnatural soaps or alkalies have touched it; no highly heated water has affected it. The natural alkali of the wool being potash, there is still left, after the true grease of the wool is removed by the solvent process, a natural soap, whose base is potash, and in most varieties of wool it remains in quite sufficient quantity to completely and thoroughly wash the wool free from dirt, without the use of any other soap whatever.

Applicable to all wools

Every variety of wool or textile hair comes from this process of cleansing in better condition than from any other that has yet been devised. Professor Bowman, already quoted, says that "the higher lustred fibres, such as mohairs

and English wools, are even more sensitive to temperature and free alkali than other wools, and hence in washing all wools, where lustre is important, the lowest temperature above 60° F. and the perfect neutrality of the soaps are indispensable."

Advantages summarized

Thus the exact conditions which are found by science to be necessary to the perfect preparation of wool for the best results in manufacture are all present in the solvent process of the Arlington Mills. The gains which follow are more numerous than is at first apparent. One of them is a considerable gain in the weight of clean fibre secured from a given amount of greasy wool, as compared with the old process of cleansing. Another is a striking reduction in the amount of noilage in combing, due to the fact that none of the staple is broken, tangled, or matted in the washing process. Still a third is the great saving in the cost of soaps and alkalies dispensed with; and a fourth appears from the use of the wool oil as a lubricant, in the place of olive oil, in the subsequent processes of manufacture. A fifth is found in the saving of the by-products of the wool, hitherto lost, the wool fat and the carbonate of potash, which will hereafter figure among the marketable products of the Arlington Mills.

These are gains which make for the advantage

of the corporation. The chief gain, and one which the corporation shares with all its customers, is the superior working qualities of the tops and yarns which are produced, the presence of a minimum of defective material, and the obvious improvement in the strength and softness of the goods which are manufactured therefrom.

The solvent plant to be doubled

Up to the present time the Arlington Mills has cleansed, by its solvent process, many million pounds of wool; and its success has been so complete, and the results secured are so highly satisfactory, that plans are already prepared for the construction of an additional plant of four kiers, thus doubling the present capacity, but with no greater cost for labor or other expense than is involved in the operation of the present plant. As the development of the business progresses, it is expected to supply facilities for applying the solvent process to the cleansing of all the wools, of whatever grades, that are used in the new combing establishment. By examining the ground plan of the Arlington Mills, upon which the location of the proposed new solvent plant is indicated, it will be seen that it is situated so far distant from the other buildings as to remove all danger to any of them, even in the improbable event of a fire or explosion.

Wool suint, or degras

Before leaving this branch of our subject, it

will interest our readers to refer to one phase of it not directly connected with the making of tops or yarns, — the saving of the wool fat or "suint." This grease is a purer form of what is commercially known as "degras," — a French word signifying literally "of fat." This particular grease possesses certain properties not exactly duplicated in any other grease, which render it a valuable adjunct in the manufacture of leather. The grease of wool possesses also exceptionally valuable qualities for admixture with lubricating oils, and it is also useful in the preparation of oils commonly used in the manufacture of woolen and worsted yarns. Its curative properties in its refined forms are also of undoubted value for medical purposes.

THE SOLVENT PROCESS

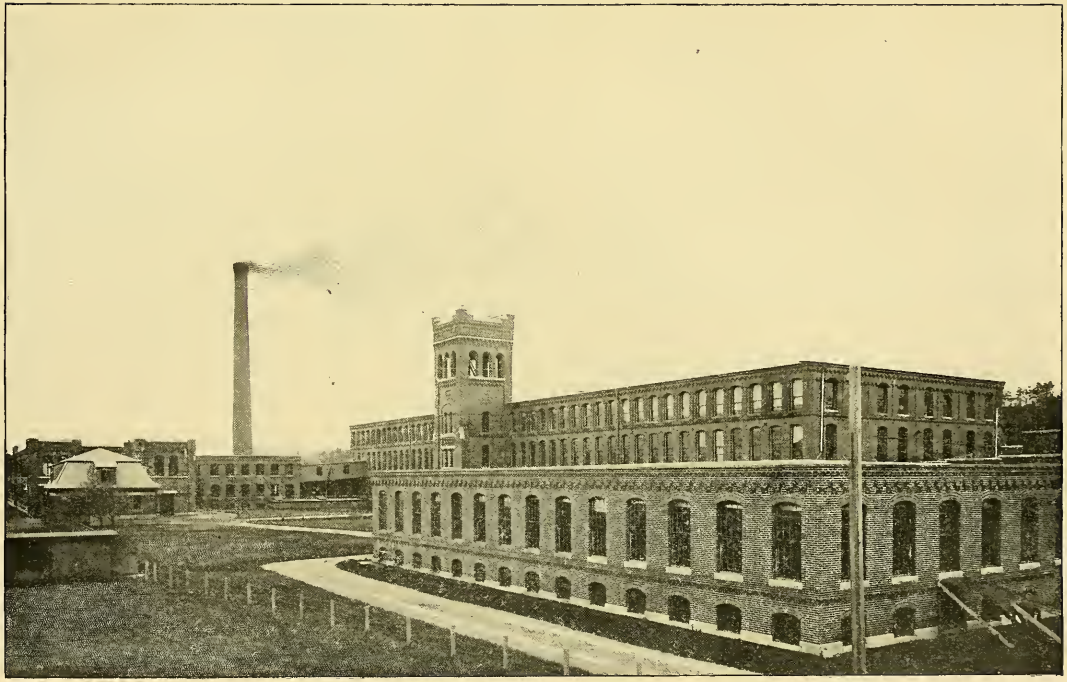
It is characteristic of our wasteful methods of manufacturing in the United States that practically all of the degras used by our enormous leather interest, aggregating about 15,000,000 pounds annually, is imported from France, while every year there runs away in the streams upon which our woolen mills are located something like forty or fifty million pounds of wool grease, — enough to supply the world with degras. This carries a pollution to the water, which in many localities is very objectionable, and will sooner or later lead to legislation prohibiting it. Indeed, the extensive French industry in degras

A valuable by-product wasted

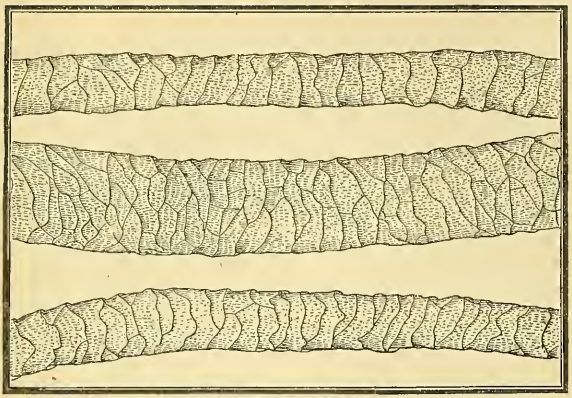
THE SOLVENT PROCESS

is said to have originally grown up because of legislation forbidding the woolen mills to allow their scourings to drain into the streams; consequently they have devised methods for saving the grease, and have built up a very handsome trade out of what was formerly a valueless by-product. In France, where wool scouring is done by the ordinary methods, the collection and refining of the grease is necessarily a peculiarly nasty process; and in the nature of things the labor employed in the industry is the poorest and most degraded that can be found in that country. We have no counterpart for such labor in this country, and in consequence it has never been thought possible to preserve the wool grease and extract the degras, in competition with the French product, even when there has been a customs duty on the latter.

All this is changed by the new method of cleansing wool adopted at the Arlington Mills. In the application of the naphtha to the greasy wool, the grease collects itself, so to speak, by the distillation from it of the naphtha which is to be used over again in the process of cleaning a fresh supply of wool.



COTTON DEPARTMENT OF THE ARLINGTON MILLS



MAGNIFIED FIBRES OF AMERICAN MERINO WOOL
(From Dr. William McMurtrie's Report)

CHAPTER V

THE HYGROSCOPIC PROPERTY OF WOOL

What this property is

ONE property of all textile fibres, known as the hygroscopic property, distinguishes wool more than any other, and now receives the closest and most scientific attention among foreign manufacturers. Thus far this characteristic has been almost ignored in the United States, in the manufacture of wool. A brief explanation will show how important it is.

The wool fibre is capable of absorbing a large

THE HYGROSCOPIC PROPERTY

amount of water without affecting its general appearance.

Exposed to a warm, dry atmosphere, wool will retain anywhere from five to ten per cent. of moisture; if stored for some time in a cool, damp atmosphere, it will readily take up from ten to twenty-five per cent. additional moisture, correspondingly increasing its weight. The silk fibre possesses this property in a marked but lesser degree; and so important a bearing has it upon commercial transactions in so high priced a fibre as silk that it has been found necessary to establish no less than thirty-seven conditioning houses, in as many principal European centres of the silk industry, where the hygroscopic condition of the fibre is determined when bought or sold. In wool transactions, the conditioning house is a somewhat later development, but such establishments now exist in half a dozen different wool manufacturing centres on the continent, and in 1888 the first wool conditioning house in Great Britain was authorized at Bradford, as a municipal institution, under the authority of an act of Parliament.

Importance of measuring hygroscopic condition

Chemists tell us that the moisture fills up the interstices between the cells of the wool fibre, which under ordinary circumstances contain air; and that it permeates also the substance of which these cells are composed. It is evident enough,

since the quantity of moisture contained in a lot of wool may vary from five to thirty-five per cent. without any perceptible difference in appearance, that the matter becomes one of great importance in connection with the buying and selling of the material. This is one of many reasons why wool buying is such a difficult business, and why it is practically impossible to determine, with exactness, what the scoured cost of any lot of greasy wool is going to be. One may ascertain the shrinkage with a fair degree of certainty; but the hygroscopic condition of the wool, at the time of purchase, is beyond ascertainment by any facilities within ordinary reach in this country. Every purchaser takes his chances as to the quantity of water he is paying for, with every pound of wool he buys, because the amount of moisture in the unwashed wool is dependent not only on the absorbing capacity of the clean wool, but also on the absorbing capacity of the potash soaps and other salts contained in the yolk. In washed wools other considerations enter; the wool which has the least tenacity, that is, in which the cells are more loosely arranged, possessing the greatest hygroscopicity. In consequence of all these variations, wool is sold more or less on the continent after an official "conditioning," which determines the exact amount of moisture in any lot.

THE HYGROSCOPIC PROPERTY

The moisture in wool

THE HYGROSCOPIC PROPERTY

A general description of the methods adopted in the continental conditioning houses is given in the Report of the Royal Commission on Technical Education, from which we make the following quotation: —

The Roubaix conditioning house

"The conditioning house of Roubaix, like the similar establishments of Lyons and Crefeld, undertakes the testing of all raw materials and manufactured goods, with regard to actual weight, measurement, and condition. Certain standards of condition are recognized in various materials, upon which allowances are made for the moisture which they contain. For example, in conditioning raw wool a given weight is placed in a receiver, through which passes a current of hot air at a temperature of from 105° to 115° Centigrade. After remaining here for about an hour, the wool is carefully weighed, and 14 per cent. is added to the weight to allow for its having been artificially dried, and to restore it to its natural atmospheric condition. Upon tops, after being artificially dried, an allowance of $18\frac{1}{4}$ per cent. is made; upon wool yarns, 17 per cent.; cotton yarns, $8\frac{1}{2}$ per cent.; silk, 11 per cent.

Percentages of regain

Cost of conditioning

"The cost of conditioning tops is reckoned on the bulk from which samples are taken, and is about 10 francs per 1,000 kilos (about one eleventh of a cent per pound).

"The house was built by the town at a cost of

£16,000. It communicates with the railway by a siding, so as to facilitate the arrival and transport of products to be tested. In 1883 the profits, after paying expenses, amounted to £8,000, which were entered in the municipal receipts and appropriated to ordinary municipal objects. THE HYGROSCOPIC PROPERTY

"A conception of the magnitude of the work carried on may be gathered from the following figures, relating to the quantities of wool, tops, yarn, etc., conditioned: —

In 1858	84,268	kilos.
In 1860	1,998,159	"
In 1869	11,653,156	"
In 1871	14,093,867	"
In 1882	19,425,434	"

"The conditioning is entirely optional. If buyer and seller agree to any transaction without submitting to the official test and the necessary expense, they can do so; but, as almost invariably happens, either buyer or seller wishes to know *what* he buys or sells, the goods are tested, and in case of dispute both parties are bound to accept the official decision." Conditioning invariably done

This book is not á scientific treatise, and therefore we shall enter into no more detailed description of the manner in which conditioning is done. On the continent, as we have seen above, the legal amount of moisture allowed is 14 per cent. on wool, 18½ per cent. on tops, and

17 per cent. on wool yarns. In Great Britain the standard allowance for regain on wool is 16 per cent. This standard has been determined by scientific verifications, based upon the average hygroscopic conditions of the atmosphere in the North of England during a year, thus determining how much moisture the absolutely dry material will regain by exposure to the open air. Whoever buys wool by this test always pays for the same percentage of moisture, no matter what may chance to be the actual hygroscopic condition of the wool at the moment of delivery.

Standard allowances for regain

Wool conditioning houses are obviously impracticable in the United States, at least for a long time to come. Whoever will recall the manner in which wool is bought and sold here will realize why this must be so. In every other great manufacturing nation, the supplies of wool are concentrated in a few markets, and bought and sold under fixed and uniform rules. Here domestic wool is picked up in lots all over the country, and every buyer depends upon his own judgment as to both quality and condition.

But such haphazard methods are not necessary in the sale of tops and rovings; nor indeed would it be possible to build up a large business in them without some definite measure of the moisture they contain. The factor is of sufficient importance to make all the difference between

Importance of condition

buying at a profit and buying at a loss. Endless difficulties have arisen, in consequence of this variation in moisture, between the buyers of imported yarns and those with whom they deal on the other side. Ordinarily, the difference is against the American purchaser, because there is less humidity in the atmosphere here than in Yorkshire. Claims for underweight, on account of this difference, have frequently been sufficient to destroy all profit to the foreigner in the transaction. Indeed, the Bradford people were fairly driven into the establishment of their conditioning house by the loss of trade which resulted from their inability to accompany sales of yarn with a certificate. The Report of the Royal Commission explains how this operated, as follows: —

THE HYGROSCOPIC PROPERTY

"Complaints were made by continental manufacturers that English yarns when they came to Roubaix were not conditioned, nor tested as to length, and that the English spinners would not submit to the Roubaix test. One gentleman stated that he had been subjected to so much annoyance in consequence of English yarns not coming up to the standard that he never bought them when he could get similar yarns elsewhere. He agreed that everybody took advantage of yarns that were known *not* to be certified. If, for instance, he sent English yarn to a dyer, and

Necessity for knowing condition

THE HYGROSCOPIC PROPERTY

deficient weight was returned, all the blame was thrown upon the spinner, the dyer knowing that no certificate of weight had accompanied the yarn. In sending English yarn to hand-loom weavers, he calculated the necessary weight and counts for certain lengths of cloth. Frequently short lengths were returned, and the weaver would invariably throw all the responsibility upon the spinner, knowing there was no proof to the contrary. With French and German yarns this was impossible, and therefore the manufacturer argued that a conditioning and reeling test protected the seller as much as the buyer, and removed the temptations to dishonesty which exist under the English system."

Conditions of humidity are not uniform in the United States, nor the same at all seasons. Without some standard of hygroscopic condition, it is evident that an element of uncertainty as to weight must always exist in domestic transactions, as it otherwise would in foreign and international transactions.

Standard for regain at the Arlington Mills

It is a part of the purpose of the Arlington Mills, in establishing this new enterprise, to establish at the same time a hygroscopic standard upon which all its business may be based. Indeed, the Mills have long been selling both tops and yarns on the basis of a fixed allowance

for regain, and the system has proved entirely satisfactory to its customers.

Much experimentation has accompanied the determination of the exact allowance for regain which should be accepted in the United States. As we have already said, the allowance on the continent is 14 per cent. for wool and in England 16 per cent., while the difference between the atmospheric conditions, here and in England, averages about one per cent. The allowance for regain in tops, at the Bradford conditioning house, is 19 per cent. when combed with oil, and 18.25 per cent. when combed without oil.[1]

[1] Mr. Walter Townend, manager of the Bradford conditioning house, writes as follows on this point: —

"I can quite understand the anomaly of 18¼ per cent. and 19 per cent. regain in tops for moisture being confusing and vague. The explanation is that 18¼ per cent. is the true regain allowable on combed wool tops on the continent (combed without oil). But from a long date back, tops combed with oil and made in the Bradford District have had a 'Trade Custom' allowance of 19 per cent. (or equal to 2 gr. 8 dr. per lb. nearly) for moisture. It was thought advisable by the authorities to continue the 19 per cent. for local trade in tops combed with oil.

"The great bulk of exported tops are combed without oil, and the regain allowance is invariably 18¼ per cent., the same as continental tops.

"Yarns here as on the continent bear a regain (officially) of 18¼ per cent. Of course, all these regains refer to moisture *only*.

"As to oil, grease, or fatty matters and insolubles (machinery dirt), there is no 'official standard;' and although we give official tests of the amount contained in either piece goods,

THE HYGROSCOPIC PROPERTY

The experiments conducted at the Arlington Mills to establish the true percentage of regain for this country have possessed a good deal of scientific interest, and have been conducted by men thoroughly competent to reach exact results, aided by the most perfect apparatus.

Experiments to determine a standard

In order that our readers may fully understand the conclusions established by these experiments, we will describe them somewhat in detail, accompanying our account of them with diagrams illustrating the results of the experiments.

During the year from the first of May, 1895, to the following first of May, Mr. William D. Hartshorne, the superintendent of the worsted department of the Arlington Mills, had accurate weighings taken, ten times a day, at approximately the same hours, for every day in the year except Sundays and holidays, of a certain skein of worsted yarn (the same skein throughout the year). This yarn was left exposed in an open shed where no artificial heat ever came, and

yarns, or tops, it is for the buyer to decide or to arrange with the seller what limit must not be exceeded. Bradford combed tops (in oil) and worsted yarns (in oil) vary according to the makers from 3 per cent. to 5 per cent. oil, etc. Some prefer more or less according to the nature of the wool, be it hard or soft to handle. Soft, silky wools naturally require less oil.

"Always at your service, I am, gentlemen,

"Yours truly,

"WALTER TOWNEND, *Manager.*"

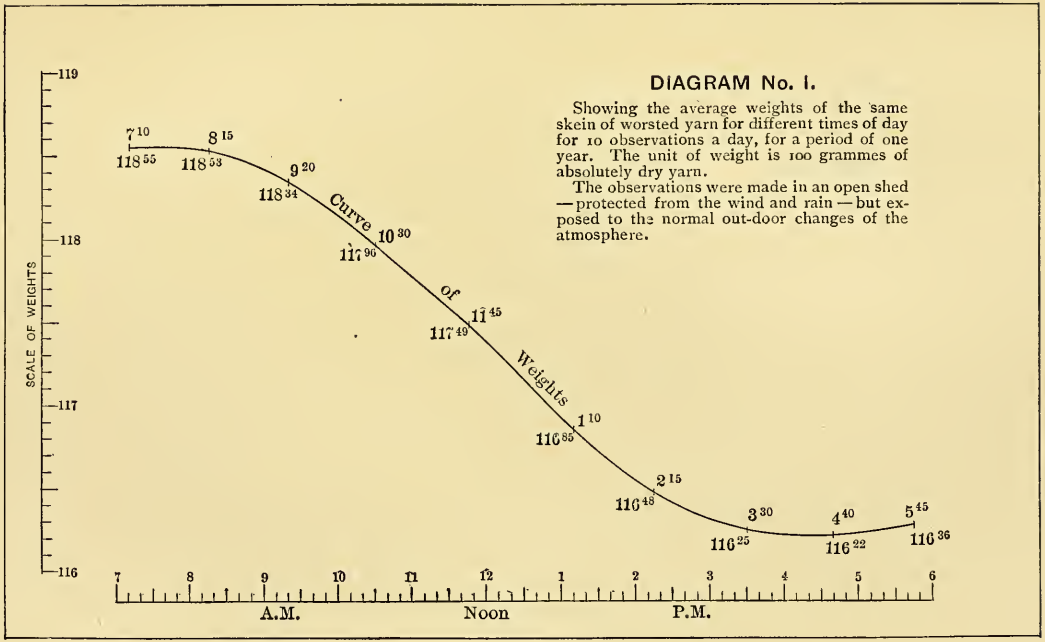


DIAGRAM No. I.

Showing the average weights of the same skein of worsted yarn for different times of day for 10 observations a day, for a period of one year. The unit of weight is 100 grammes of absolutely dry yarn.

The observations were made in an open shed —protected from the wind and rain — but exposed to the normal out-door changes of the atmosphere.

from which wind, sun, and rain were excluded, but which was otherwise exposed to the outside influence of the atmosphere. THE HYGROSCOPIC PROPERTY

The great variations observed in the weight of this skein of yarn were remarkable. The moisture it contained ranged from a little over 7 per cent. to as high as 35 per cent. of its total weight, often with a variation of from fifteen to twenty per cent. in twenty-four hours. For the purpose of discovering the law of variation, if there was a simple one, all the observations for each particular hour were arranged together so that a curve could be plotted, representing what might be called the average curve of change. This curve is represented in the accompanying diagram marked No. 1. In this diagram, the figures above the line, $7.^{10}$, $8.^{15}$, etc., show the hours of the day at which the observations were taken. The figures below the line, $118.^{55}$, $118.^{53}$, etc., show the average of the weighings, on the basis of one hundred parts, absolutely dry, of this skein at these represented hours. It will be seen that the early morning hours are the time when the absorbing capacity of the yarn was greatest, or, rather, when the amount of the moisture it could obtain from the atmosphere was the greatest. Between the hours of three and four o'clock in the afternoon, the amount of moisture absorbed was the least, Description of the curve diagrams Diagram 1

THE HYGROSCOPIC PROPERTY

and the difference in the amount absorbed, at the two periods of time, was for the average about two per cent. The lines which could be plotted for each day in the year would, of course, differ very widely at points from this average line, varying according to the temporary variations in the condition of the atmosphere.

Diagram 2

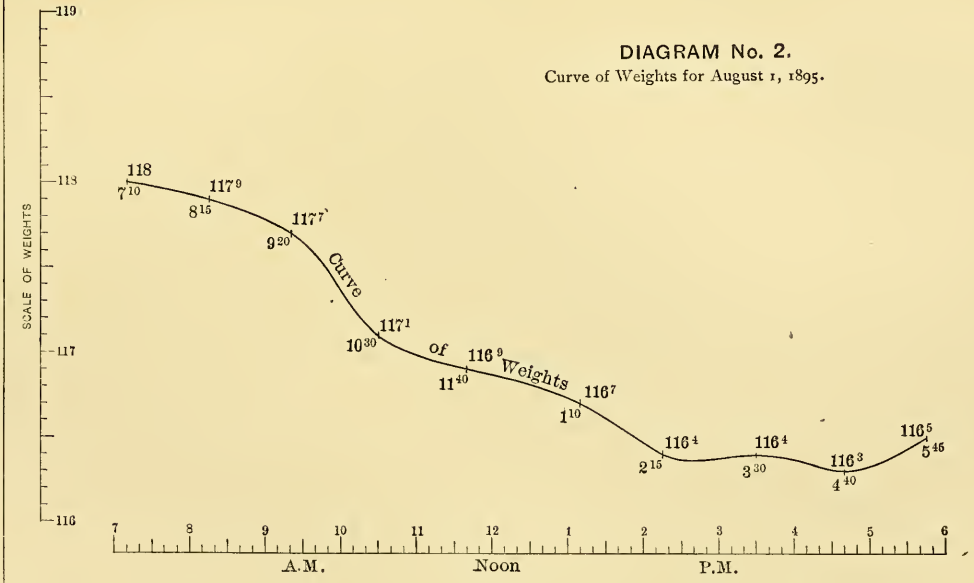
Diagram No. 2 shows the line of curve for the first day of August, and it is approximately in accord with the average line for the whole year, but showing nevertheless the natural variations from the average curve.

Diagram 3

The third diagram, plotted on a slightly smaller scale to allow for two days to be shown together, indicates the great variation which took place in the weight of the skein of yarn between October 31 and November 1. Starting at 115^2 at 7.10 in the morning of the first day and reaching 118 at 5.45 in the afternoon of the same day, the increase in moisture continued through the night, as may be represented by the dotted line, until, at 7.10 on the morning of the next day, the skein obtained the weight of 126 parts, falling gradually from that point, until it reached 116 at the close of the day. These two days are chosen for representation by diagrams because they show a variation which, while rapid, was not unusual nor extreme when compared with many other days throughout the year.

DIAGRAM No. 2.

Curve of Weights for August 1, 1895.



Simultaneously with the taking of the observations above described, humidity observations were also made at the Arlington Mills, by means of the wet and dry bulb thermometers, in the usual manner, and a record was kept of the so-called relative humidity of the atmosphere at the time of each observation, except at certain periods of extremely cold weather, when the difference of readings between thermometers was not sufficient to determine the amount of the humidity. These humidity rates and the corresponding temperatures were averaged in the same manner as the weights of the skein of yarn, for the respective hours of observation.

THE HYGROSCOPIC PROPERTY

Humidity observations

Diagram No. 4, based upon these averages, shows the temperature curve and the humidity curve in comparison with the weight curve. The weight curve here given differs slightly from that shown in diagram No. 1, owing to the omission from it of several weeks of time, during which the humidity observations could not be applied. In all other respects it is the same.

Diagram 4

The relationship between the weight curve and the humidity curve is instantly perceptible. That is to say, the weight curve is highest at that portion of the day when the humidity curve is the highest. There is also a relationship between the temperature curve and the weight curve, in that the highest point of the weight

Weight, humidity, and temperature

THE HYGROSCOPIC PROPERTY

curve corresponds to the lowest temperature. Through the day, until about one o'clock, the humidity and weight curves fall rapidly and the temperature rises, but after that hour, notwithstanding the fact that the humidity begins to rise again, the weight curve continues to fall so long as the temperature continues to rise, or until about 3.30 P. M. The fall of temperature and continued rise of humidity from that period through the night result in bringing back the skein weight to the starting-point of the morning.

That there is a scientific relationship between these three elements is sufficiently determined by the experiments whose results are recorded in these diagrams. To state that relationship in an exact scientific formula may, however, be impossible; and it is altogether probable that the height of the barometer has an important relationship to the problem.

Allowance for regain

But the investigations sufficiently determine the fact that the average exterior condition in this country, or at least for the particular skein experimented with in the city of Lawrence, is a little lower, in respect to moisture, than the recognized standard in England and on the continent; that is to say, it appears to be about $17\frac{1}{2}$ per cent. instead of $18\frac{1}{4}$. As the establishment of a standard allowance, as a basis for buying and selling, was of more importance than

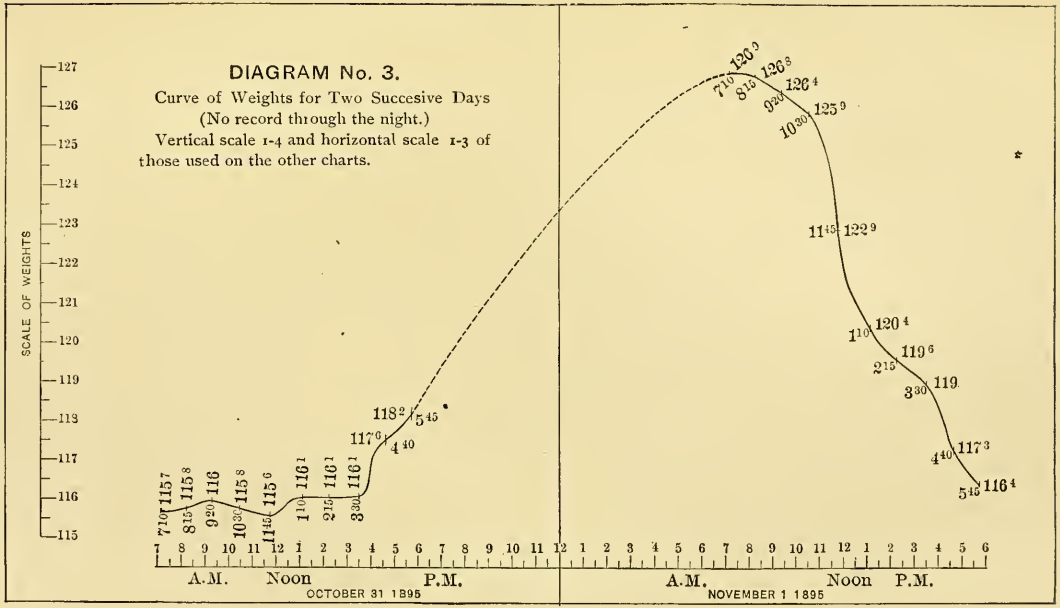


DIAGRAM No. 3.
Curve of Weights for Two Succesive Days
(No record through the night.)
Vertical scale 1-4 and horizontal scale 1-3 of those used on the other charts.
SCALE OF WEIGHTS
127
126
125
124
123
122
121
120
119
118
117
116
115
7 10 115 7
8 15 115 8
9 20 116
10 35 115 8
11 45 115 6
1 10 116 1
2 15 116 1
3 30 116 1
4 40 117 6
5 45 118 2
7 10 120 9
8 15 120 8
9 20 120 4
10 30 120 9
11 45 122 9
1 10 120 4
2 15 119 6
3 30 119
4 40 117 3
5 45 116 4
7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6
A.M. Noon P.M.
OCTOBER 31 1895
A.M. Noon P.M.
NOVEMBER 1 1895

the actual amount of the allowance established, the Arlington Mills had already accepted the popular idea that the rate for this country was naturally less than for England and the continent; and to be conservative, had placed it at 15 per cent. This rate has since been adopted by several other manufacturers. THE HYGROSCOPIC PROPERTY

In connection with this question of the hygroscopic property of wool, there is another closely related, which has a bearing upon the ability of American yarn spinners to produce satisfactory worsted yarns, and some remarks concerning which may not be out of place in concluding this chapter. It has to do with the general question of atmospheric conditions, in their bearing upon worsted yarn spinning. Humidity conditions in the United States

In 1885 there was a Royal Commission appointed in Great Britain to inquire into the depression of trade and industry in the United Kingdom, which at that time was keenly felt in all lines of enterprise. Many expert witnesses were called before this Commission, among the number, Mr., now Sir Henry, Mitchell, one of the largest and most successful of the Bradford manufacturers and merchants. In the course of his testimony, Mr. Mitchell made the following statement: — Sir Henry Mitchell quoted

"I do not think the Americans will ever be able to make yarns so good as we can in this

THE HYGROSCOPIC PROPERTY

country. The climate of the United States is very unfavorable for the spinning of worsted yarns. The very great changes that take place, the intense heat in summer and the intense cold in winter, are very unfavorable to the spinning of worsted yarns; a moist climate is more suitable for them. This does not apply to the same extent in Germany. I think it likely that Germany in time will be able to supply their own manufacturers with those yarns."

An exploded theory

This statement is based upon a theory which prevailed very generally up to a comparatively few years ago, and which, until science had overcome the difficulties alluded to, was abundantly well founded. It accounts in very large measure for the extraordinary concentration of the cotton spinning industry in Lancashire, England. Some one has said that that little corner of the island is the moistest spot in the world. Yorkshire, where three fourths of the wool worked up in Great Britain is manufactured, is only less moist than Lancashire. The supposed greater humidity of the atmosphere at points like Fall River and New Bedford was among the reasons which led to the unusual concentration of the domestic cotton manufacture at those points. It goes without saying, however, that the interior condition of mill buildings, unless artificially maintained at a

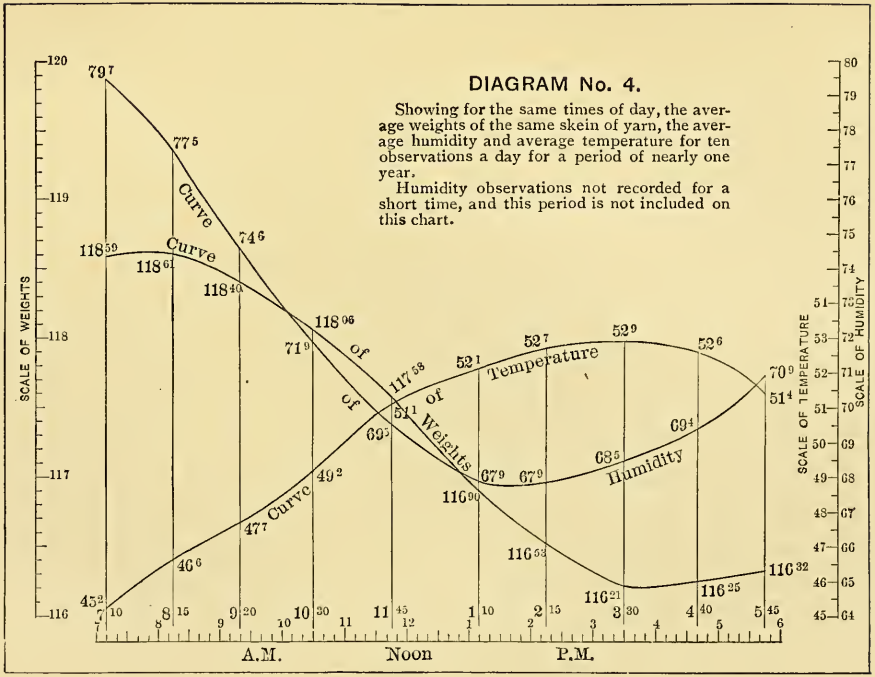


DIAGRAM No. 4.
Showing for the same times of day, the average weights of the same skein of yarn, the average humidity and average temperature for ten observations a day for a period of nearly one year.
Humidity observations not recorded for a short time, and this period is not included on this chart.
SCALE OF WEIGHTS
SCALE OF TEMPERATURE
SCALE OF HUMIDITY
Curve of Weights
Curve of Temperature
Curve of Humidity
A.M.
Noon
P.M.

uniform state of moisture, will differ very materially from the exterior conditions, particularly in the winter time. The cold weather of winter freezes out, so to speak, the moisture of the atmosphere, and although the relative humidity may be large out of doors, the absolute amount of moisture in a cubic foot of air is very much less, and when this air comes within a room and is heated up to a comfortable temperature, the relative amount of moisture is very much below the normal, creating the condition of high temperature and low humidity, which is very detrimental to the successful spinning of either cotton or worsted yarns.

THE HYGROSCOPIC PROPERTY

It was this fact which led Sir Henry Mitchell to state, twenty years ago, that the Americans would never be able to make as good worsted yarns as are made in Great Britain. But he overlooked, in his diagnosis of the situation, the power of science and invention to overcome natural conditions. The difficulties alluded to were of a kind which long ago called for a scientific solution, which has been found and applied in the shape of humidifiers, which enable those in charge of a mill to regulate the moisture in a room to that fraction of the degree which is found in practical experience to be the best adapted to the production of given results. This is secured at the Arlington Mills by the

Artificial humidification.

THE HYGROSCOPIC PROPERTY

direct weighing, upon an automatic balance, of the absorbing capacity of the particular material which is in process, and the regulation of the humidity of each room accordingly.

Intelligent readers do not need to be told that a status of humidity which can be maintained continuously at the exact point which is found to be most desirable, is far preferable to one which is dependent upon outside atmospheric conditions, varying, as these latter must, from day to day and week to week. In other words, better and more uniform results can be secured by artificial means than are possible in a mill room, whether located in Lancashire or Fall River, where nature is left to determine the matter at her own sweet will. In evidence of this is the fact that the best mills at Manchester and Bradford, like those of our own country, now regulate the humidity of their spinning-rooms by artificial means.

If Sir Henry Mitchell were given an opportunity to revise his testimony of 1885, he would drop from it the paragraph we have quoted above and rejoice at the chance. We can and do spin in the United States just as good worsted yarns as can be spun anywhere in the world.

NOTE. — In order that readers interested in this question from a scientific point of view may possess fuller

data regarding these interesting experiments than is given in the text, we annex an analysis of the observations for moisture by months : —

AVERAGE OF ALL OBSERVATIONS FOR MOISTURE.

May,	1895	=	14^{80} %	17^{45} % for year as averaged by the month.
June,	"	=	16^{87}	
July,	"	=	18^{05}	
August,	"	=	17^{31}	
September,	"	=	17^{29}	
October,	"	=	16^{76}	
November,	"	=	22^{02}	
December,	"	=	19^{28}	
January,	1896	=	17^{40}	
February,	"	=	17^{21}	
March,	"	=	17^{21}	
April,	"	=	14^{15}	

ANALYSIS OF OBSERVATIONS.

	Lowest Day.		Highest Day.		Lowest Observation.		Highest Observation.		Greatest Difference in 24 hrs.	
	%		%		%		%		%	
May.....	11^{60}	17th	21^{50}	27th	9^{7}	17th	22^{0}	6th and 27th	8^{2}	6th to 7th
June	13^{01}	19th	25^{92}	29th	10^{7}	14th	27^{5}	28th	10^{0}	5th to 6th
July.....	14^{95}	25th	23^{96}	17th	12^{9}	3d	26^{6}	1st	9^{1}	1st to 2d
August....	14^{45}	9th	22^{00}	13th	12^{6}	21st	22^{9}	13th	8^{7}	7th to 8th
September.	12^{19}	24th	23^{27}	11th	11^{5}	24th	25^{9}	26th	12^{1}	26th to 27th
October....	13^{61}	18th	22^{71}	8th	12^{2}	18th	28^{0}	14th	11^{3}	28th to 29th
November .	15^{59}	22d	31^{77}	26th	14^{1}	4th	35^{1}	26th	19^{1}	26th to 27th
December .	15^{41}	27th	30^{70}	2d	13^{0}	27th	33^{7}	2d	16^{1}	2d to 3d
January....	13^{54}	4th	34^{26}	25th	13^{0}	29th	34^{9}	25th	15^{1}	24th to 25th
February ..	12^{79}	25th	29^{92}	6th	12^{2}	25th	33^{4}	6th	17^{3}	6th to 7th
March.....	11^{93}	27th	27^{30}	2d	10^{2}	27th	28^{8}	20th	16^{4}	30th to 31st
April.....	9^{03}	30th	21^{89}	2d	7^{3}	30th	24^{0}	2d	12^{2}	1st to 2d

General average (by the month) for the year, 17^{45} %.

Lowest average period, April, '96, 14^{15}, and May, '95, 14^{86} %.

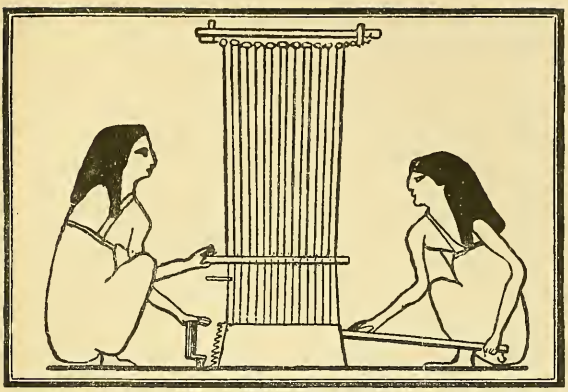
Highest average period, November, '95, 22^{02}, and December, '95, 19^{28} %.

Lowest observation, April 30th, '96, 7^{3} %.

Highest observation, November 26th, '95, 35^{1} %.

THE HYGROSCOPIC PROPERTY

The greatest variation in 24 hours occurred between the 26th and 27th of November, '95, and was 19^{1}. A still greater rate of variation was shown on March 20, the observation showing 28^{8} % at 7.10 A. M., and 13^{4} % at 5.45 P. M., a difference of 15.4 % in ten hours.



EGYPTIAN WEAVERS AT A VERTICAL LOOM
(From the Tombs of Beni Hussan, Thebes, as found by Menutoli)

CHAPTER VI

HOW TOPS WILL BE SOLD

How the standard is applied

HAVING described the hygroscopic property of wool, and the methods adopted to establish a hygroscopic standard for the United States, it now becomes necessary to explain how this standard is applied, in the selling of tops at the Arlington Mills.

The greatest care has been exercised in determining this standard, to fix upon that one which will prove the most acceptable to all manufacturers and dealers, in the expectation that it may

HOW TOPS WILL BE SOLD

eventually come to be a generally recognized standard. The managers of the Arlington Mills are not alone in the conviction that it is a loose and unbusinesslike method of carrying on business, to ignore considerations of this character, which bear so intimate a relation to the profit or loss of the transaction. It seems more than likely that within a comparatively short time the practice of making proper allowance for regain will become general in this country; and if the Arlington Mills shall succeed in promoting this simple and sensible reform, it will have achieved something for the wool manufacturing interests of which it can be proud.

Why private initiative is necessary

In the mean while, the conditioning of tops and yarns must necessarily stand on a different basis at the Arlington Mills from the one it occupies in other countries. As already said, the foreign conditioning houses are legalized by statute, and the certificate of the conditioning officer is binding, in all transactions, and conclusive, in case of any dispute. The Bradford conditioning house is owned and operated by the municipality, and all certificates granted are legal evidence in courts of law.

In the absence of any legalized institution here, the Arlington Mills is under the necessity of establishing its own conditioning house, and certificates of condition will accompany invoices,

THE ALPACA, PERU

without charge to the customer. All shipments of tops made therefrom will be accompanied by the certificate of the person charged with this duty, and all prices will be based upon an allowance of 15 per cent. regain; goods will be sold upon this basis, no matter what may be their exact hygroscopic condition on the exact day and hour of shipment. This certificate will be guaranteed; and the purchaser can satisfy himself as to the accuracy of the tests made, either by witnessing the operation or by making the test himself. We are aware that this latter suggestion may not seem to be altogether feasible, in view of the fact that expensive apparatus and exact scientific knowledge are necessary to determine the proper allowance for regain. But it will be clear that no one has so much at stake, in the absolutely accurate ascertainment of this allowance, as the Arlington Mills, whose ability to retain its customers depends upon fair treatment of them.

HOW TOPS WILL BE SOLD

The sale of tops on the basis of a certificate of condition is the only method of sale which is perfectly fair to both buyer and seller. On no other basis can the seller know just what he is selling, or the buyer just what he is buying. The need for a definite standard is as important in the case of tops as in that of yarns.

Fair to buyer and seller

A careful consideration of all these facts has

HOW TOPS WILL BE SOLD

led to the conclusion that it is impossible to look for a large development of business in tops in this country, unless at its inauguration there is established a thoroughly scientific method of ascertaining, with respect to each sale of tops, precisely what the hygroscopic condition is at the time of delivery, measured by an accepted standard as to just what it ought to be, the price to be determined by adjustment to that standard. No other method will give the purchaser perfect security as against the seller, in whose hands the power would always otherwise lie to profit by the greater or less degree of moisture, above the accepted standard, which might be found in the top at the time of shipment.

Growth of the Bradford conditioning house

That we are not too sanguine in our anticipation of the advantage our customers will find in this method of purchasing our products may be fairly inferred from the experience of the Bradford conditioning house. It is a comparatively recent institution there, having been in actual operation only since 1890. It is curious to read that for many years the Bradford manufacturers were stoutly opposed to its establishment, holding, with their customary conservatism, that they had always done business in the old-fashioned way, and that was a good enough way for them. But after five years' experience, nothing would induce them to part with it. The

best evidence of its utility is the statistical record of the increase in its business from year to year, which is as follows: — HOW TOPS WILL BE SOLD

	1892	1893	1894	1895
Total weight materials tested, lbs.	2,576,190	5,286,500	9,560,842	14,350,000
Total number of tests made,	8,146	15,062	26,168	34,024
Fees received,	£500	1,100	1,530	

Here is indicated an enormous increase in business — so great, in fact, that the conditioning house long since outgrew its original quarters and has moved into more commodious buildings. Inquiry of Mr. Walter Townend, the efficient manager of the Bradford conditioning house, elicits the fact that of the material passing through it from year to year, about 55 per cent. is for the home trade, the remainder being chiefly for the continental export trade.

It is not difficult to understand why the conditioning house has grown so quickly popular in Bradford. It is the guarantee of an absolutely honest transaction wherever it intervenes. It is equally for the protection of the buyer and the seller. Business has now to be done on such close margins that exactness is essential to success; and exactness in the products of wool is possible through no other instrumentality. A guarantee

The different situation in the United States not only requires different methods of ascertaining condition, in the sale of tops, as above indicated, but it also requires methods of conducting

HOW TOPS WILL BE SOLD

the whole business radically different from those which prevail abroad, as we may now proceed to show. We have described in Chapter II. the Antwerp and the Bradford methods of dealing in tops. One distinguishing difference between these two systems must now be pointed out, as the basis of a demonstration that the method introduced by the Arlington Mills combines all the advantages of both, without the disadvantages of either.

The English method of top making

The English combers comb on commission, not universally, it is true, but such is the general practice. The manufacturer or merchant makes his own purchases of wool, according to his needs; the comber receives it in the bale and it passes through his machinery at a certain given price for combing, according to the quality of the stock and the purposes for which it is to be used. To conduct business in this way requires a number of separate compartments at the mill, one for each customer, into which that customer carts his stock, and to which he alone has access. Here he sends his own sorters and makes his own mixes; and thence his wool goes to particular machines adjusted to his particular work. The arrangement requires a careful system of secrecy and surveillance, so that one manufacturer shall not know the kinds of wool or the qualities of blends which a rival manu-

facturer is employing. The comber himself knows nothing about it and cares nothing about it. He makes tops out of whatever is brought to him, at so much per pound. Whether their quality is good, bad, or indifferent is the concern of the manufacturer only, — at least until the consumer's turn arrives.

HOW TOPS WILL BE SOLD

At Antwerp the comber is himself the purchaser and owner of the wool which he converts into tops; and it is his business to make a standard quality, up to market requirements, by the exercise of all the ingenuity he can command in the selection and blending of his stock. The fate of the goods made from his tops is not his concern. What he produces loses its individuality in a mass of tops, made nobody knows where or by whom, and thrown upon the market in an indiscriminate lump. The buyer of those tops takes his chances; and if product goes wrong, he has no one to fall back upon.

The Antwerp method

The Arlington Mills method is neither the Bradford nor the Antwerp method; and its advantages over either or both will be instantly apparent. The spinner in need of tops can buy what he wants, in quality of stock, as at Antwerp, with a guarantee of that quality such as Antwerp cannot supply.

The Arlington Mills method

He can purchase in larger or smaller quantities, according to his necessities or capital, with-

HOW TOPS WILL BE SOLD

out being compelled, as at Bradford, to buy his own wool and take his chances of making an advantageous disposal of the sorts unsuited to his purposes.

Some of the advantages

In a word, the Arlington Mills will comb tops for sale, in any quantity, from any quality of stock, to be delivered according to the requirements of the manufacturer. It will buy the wool and buy it to the best advantage, because the immense quantity it annually consumes compels it to have its agents at all the great wool sales of Europe, Australia, and South America.

The great stocks of wool which the exigencies of its business compel the Arlington Mills to have always on hand in its storehouses permit of a much wider choice, in the selection of sorts, than would be possible to any purchaser except he were a purchaser on an equally large scale. It permits the filling of exigency orders at short notice, much shorter than would be possible if it was necessary, with each order, to go into the market and search for the proper stock.

It will enable manufacturers to carry on their business with a much smaller capital, and to turn such capital as they have much more quickly and frequently. No capital must be locked up in the storehouses. Not until the top is actually delivered, ready for the spinning frame, does the raw material become a charge

on the capital, a gain in the matter of time which may often amount to six months or even more.

HOW TOPS WILL BE SOLD

Above and beyond these advantages is the additional one conveyed in the guarantee of the quality of the stock. Long experience in the manufacture of tops implies superior knowledge as to how to get the best possible results. The management of the Arlington Mills believe they have solved the problem of superior top making. They have investigated the processes in use in the best combing establishments abroad. Their mills are equipped with the most recent and the most perfect machinery, with every appliance for perfect work which mechanical ingenuity has been able to suggest. Their sorting is conducted under the most rigid supervision. Their system of inspection is so complete that defective work can hardly escape detection. All these advantages, the result of years of patient experiment and study, will be at the command of their customers. The risk of mistake is reduced to the minimum. More than that, the responsibility for mistake is assumed by the top maker.

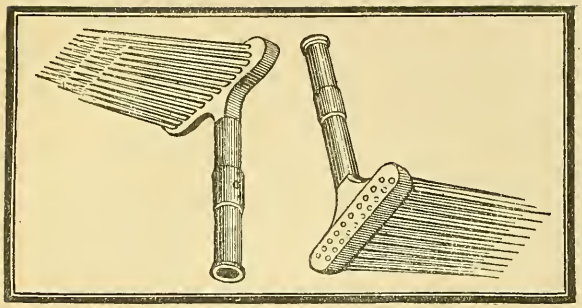
Quality of stock

The difficulties which surround the manufacture of perfect worsted yarn are well known to all those who have attempted it. They are greater probably than in any other branch of the textile

Perfect yarn making

HOW TOPS WILL BE SOLD

manufacture. These difficulties are nearly all of them incident to the stages of manufacture prior to the drawing and spinning. Given a perfect top, exactly suited to the yarn required, and it is a comparatively simple matter to secure a perfect yarn from the spinning frame. The spindles work automatically; with proper care and attention, they will always do the same quality of work, provided they are always fed with a uniform quality of top.



A Pair of Hand Combs

CHAPTER VII

THE MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

AT the head of this chapter appears an illustration of a pair of hand combs, similar to those with which, up to about sixty years ago, all the wool used in the world for the worsted manufacture was prepared for the spinner. One of these combs, called the "pad" comb, was fixed to a post by an iron rod, and the raw material, properly prepared, was lashed into the "pad" comb, and placed in a stove called the "comb pot;" when the wool was properly heated, the comber began his work, one comb upon the post, the other held in the hand, each comb becoming a working comb alter- Hand combing

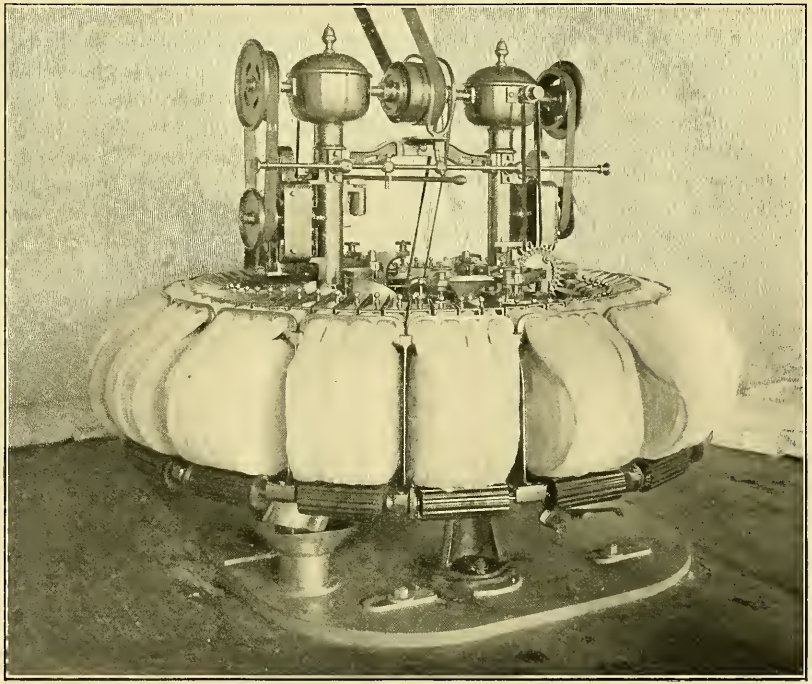
MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

nately, the teeth of one passing through the tuft of wool upon the other, until the fibres became perfectly smooth, parallel, and free from noil. This work was always performed at the home of the comber, and it was regarded as the most delicate and difficult of all the operations connected with the textile manufacture. Wool combers, in the early half of the century, were quite the aristocracy of the industry, and received the highest wages paid to any class.

The combing machine

No contrast between old and new industrialism is more striking than that between this old method of combing and the modern methods. On another page appears an illustration of a modern comb, charged with wool in process of manufacture; and, comparing its complex parts with the above description of hand combing, one has no difficulty in accepting the statement of a French writer, that its action more nearly approaches the deftness of the human hand than that of any other machine ever invented. Mr. Burnley, in his "History of Wool and Wool Combing," has drawn so graphic a picture of a wool-combing room that we are tempted to quote it. "Here," says Mr. Burnley, "are rows upon rows of wool-combing machines. As a piece of mechanism, each of these machines is beautiful to look upon; the brightness of its appearance, the unerring exactness of its movements, and the

Mr. Burnley quoted



A NOBLE COMBING MACHINE, 1897

more than human dexterity with which it handles the fibre, all combine to excite admiration. All that is required of the attendants is to see that the combs are kept strictly clean and clear, and that no obstruction is permitted to interfere with the ingress and egress of the woolly filament. The combs move round the machines horizontally, each separate comb forming a segment of a circle of combs, and being fed by a couple of feeders which imitate the motion of the old hand comber and rise and fall with great rapidity. Looking across these bright rows of combing machines, this continuous rising and falling movement of steel-toothed instruments constitutes an exceedingly striking picture. The horizontal combs convey the wool round to drawing-off rollers, and at that point the fibre issues from the machines in its combed condition, falling in white, lustrous, delicate filaments into tall tin cans placed for its reception. The beautiful operation, upon which so much human ingenuity, skill, patience, and such a vast amount of money have been expended, is now complete."

A combing-room

This contrast between the hand comb and the machine comb is suggested by the fact that so lately as August 14 last, at his princely home near Bradford, in England, died Sir Isaac Holden, the man who, in conjunction with Sam-

Sir Isaac Holden

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

uel Cunliff Lister (now Lord Masham, and still an active business man), first brought the combing machine to that point of perfection where it became possible to operate it to advantage. These men were given titles by the Queen just as Richard Arkwright was knighted a hundred years ago, in recognition of their extraordinary services in the development of England's great specialty in the wool manufacture. They both accumulated gigantic fortunes, the just rewards of their ingenuity and their indomitable perseverance in overcoming mechanical difficulties which other men declared to be insuperable.

Richard Arkwright

Thus the lifetime of men yet living covers the real development of an industry which existed in England, in its primitive state, before the industrial annals of that country began to be recorded. There are in the employ of the Arlington Mills men who left the old country, where they had been hand combers, because the introduction of the Holden and Lister machines had deprived them of the occupation to which their lives had been trained. It is estimated that at the time referred to — between 1845 and 1855, when the mechanical comb was generally introduced in the English worsted mills — there were some 20,000 men employed, in all parts of the kingdom, in the highly paid and

Introduction of machine combing

highly expert business of the hand combing of wool.

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

The introduction of the machine was bitterly and even riotously resisted by the hand combers, just as the use of the spinning frame had been resisted by the hand spinners nearly a century earlier, on the ground that it was a devil's device to take the bread from the mouths of their families. Indeed, Mr. Holden, who was a man of great heart and humane instincts, was much troubled in the early days of his career as an inventor, by the fear that his success would bring suffering and want to a great body of industrious men. At a later period in his life, speaking on this phase of the subject, Mr. Holden said that when he established his wool-combing works in France there was a population of about 5,000 in the adjacent village, while to-day the same town contained a population of 240,000 souls, the great majority of whom owed their living directly or indirectly to the industries which had grown up out of his wool-combing establishment. It would seem to be sufficiently plain that this great invention, so far from permanently displacing workmen, has enormously increased the opportunities for employment.

What machinery has made possible

Sixty years ago, 20,000 wool combers worked up all the wool consumed by the English

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

worsted manufacture, and the industry hardly had a footing in any other country. To-day two million hand combers could not prepare the wool which the worsted manufacture eats up each year by the aid of machines which employ twenty times the number of operatives that the industry required before the machine superseded the man in this particular process.

We recite these somewhat familiar facts, because they show vividly how comparatively recent the real worsted manufacture is, as now organized. It is the newest of all the textile industries, from that point of view, and therefore the one whose future offers the largest opportunities. Revolutionized as to its fundamental process within the lifetime of men now engaged in it, it offers possibilities of future growth, for the measurement of which there is no standard in the past; and it is far more adaptable to those changes in methods, the coming of which we foresee in the United States, than would otherwise be the case. It is still in that state of flexibility, incident to the comparative newness of the conditions governing its extension, which renders an innovation, like the proposed special manufacture of tops, by no means so radical a new departure or so doubtful an experiment as it may appear at first thought.

Possibilities of future growth

The force of this will be made more apparent

by reverting again for a moment to the sister industry of the woolen manufacture. There are but few woolen mills in the United States that do not spin their own yarns, just as they have been doing ever since the American revolution. Change from the old methods in that branch will necessarily be slow, not alone by reason of the conservative influence of long custom, but because this very conservatism kills any incentive to supply the facilities for effecting a change. If woolen yarns were purchasable in all varieties and counts, a market would doubtless grow up for them in time. The facility with which worsted yarns can be obtained has enormously added to the sale of them; and such, we have faith to believe, will now be the case with tops.

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

The successful achievement of the combing machine may be said to have disposed of the last of the fundamental inventions required in the mechanical manufacture of the wool fibre. There remains no single process, of an important character at least, — no process which involves any fundamental mechanical principle, which is not now performed by machinery.

Rapidity of recent progress

As the worsted manufacture was the last to come completely under the domination of the machine, it has necessarily been the one in which the most rapid progress has been made during the last half century, and even during the last

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

ten or a dozen years. As all the collateral machinery now used in the processes preliminary to spinning depended upon the combing machine, it follows that in their essential features all these machines have been brought to their present degree of efficiency since the invention of the combing machine. In these machines improvements have followed rapidly upon each other's heels; hardly a year passes without the application of some new device for the expediting or the simplifying of the various processes, — devices which have made the manufacture pratically automatic from start to finish. These inventions and improvements, since they have involved no modification in the fundamental principles of manufacture, have created no such stir in the world as did the invention of the combing machine; but they are hardly less important, in their general relation to the problem of large production with the best results.

Large production with best results

This may be said to be the one great problem of modern manufacturing, so far as it relates to semi-manufactured articles like yarns and tops, into the making of which there enters no question of design, pattern, color, or adaptability to popular taste, and where the sole ends to be obtained are uniformity and quality.

Under such conditions, excellence of product is possible, in connection with the very largest

production of which a given amount of machinery is capable. Given a proper selection and preparation of stock in the first instance; given machinery which does its work perfectly and uniformly, then the excellence of the product may be kept at a uniformly high standard, while the production of the machinery continues to increase by reason of the various improvements to which we have alluded.

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

It was at once realized, after the combing machine was perfected, that the wool emerged from it in a far better condition than had been the case with hand-combed wool. There is now a uniformity and evenness about the treatment of the fibre which it was impossible for the most expert hand comber to attain. So it has been found that the progressive improvements in combing-machines, gill-boxes, back-washers, and other preparatory machines which have constantly tended to increase the quantity of production, have at the same time increased the quality of the product.

Quantity and quality

To illustrate this from the experience of the Arlington Mills, it may be said that important instrumentalities in effecting the increased production of the combs now in use there are nicer accuracy of adjustment in circles, and the much more substantial foundations upon which the machines are erected. It is self-evident that

Some recent mechanical improvements

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

improvements of this character have as important an effect upon quality as upon quantity of production.

Another illustration will tend to show how rapid recent progress in the manufacture is. Ten years ago, in all our worsted spinning mills, one man tended one comb. At the present time, that same man will easily tend two combs, on the same quality of stock, and the production of each comb is more than double what it was. To state the matter mathematically, there has been an increase of from four to five times in the product which comes from one man's labor, due wholly to improvements in the machinery he attends. These improvements are of such a character that the actual physical effort of the workman is no greater than formerly, if as great, — and the improvements which require less labor on his part, in a given result, necessarily result in an improved quality of product with the greatly increased quantity, because formerly his labor very largely consisted in watching and correcting the defective work of the machine.

Larger doffings

Other illustrations from other departments of a mill will show what important results, in the way of increasing product while improving quality, follow from comparatively small causes, — small, that is, in comparison with the great inventions which revolutionize the whole methods

of an industry. In spinning, a doffing would formerly weigh $3\frac{1}{2}$ pounds; the bobbins now used are so much longer and larger that a doffing will weigh from eight to nine pounds, the gain in production corresponding, without any loss in quality.

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

The speed of worsted spindles has been gradually increased from 5,000 or 6,000 revolutions to 7,000 or 8,000 revolutions a minute; and the methods by which this increased speed have been secured are such as to insure a more perfect uniformity in the quality of the yarn.

Speed of spindles

This advance, in connection with the improved methods of putting up and dressing warps, so that the ends do not come down so often, enable one weaver to attend six looms to-day, as easily as he could two looms ten years ago. It is self-evident that when six looms require no more personal attention than two looms recently required, it must be because the looms are doing better work than formerly and producing a better-woven fabric, with fewer defects.

Looms

The more perfect the workmanship of a given machine, the greater becomes the producing capacity of a given number of operatives, set to tend the machine. You can increase indefinitely the number of machines attended by the single operative, provided you correspondingly increase the automatic perfection with which

Increase of individual productivity

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

each machine performs its work. You cannot increase the efficiency of the machine without improving the quality of its work. So it is that from year to year a given number of operatives, in an up-to-date mill, is continually increasing the quantity of its product, while the quality is always improving. The evolution of manufacturing is a constant record of more machines to the man; but in order to understand it, it is necessary to remember that there cannot be more machines to the operative unless they are better machines.

A popular error corrected

We are reciting facts so perfectly familiar to manufacturers that it may seem a work of supererogation to repeat them in a publication of this character. But it is necessary to repeat them if we are to convey to the lay reader an intelligent conception of the reason why the constantly increasing productivity of modern machinery is accompanied by a corresponding improvement in the quality of the product. The popular impression is just the other way. It is an impression fostered, we regret to say, by many of our writers and teachers on industrial economics, — men who no doubt state their own impressions with all sincerity, and who draw erroneous conclusions only because they are necessarily unfamiliar with the actual conditions which prevail in manufacturing to-day, and which under-

lie the extraordinary increase in productivity of which they are vaguely aware, and which they scholastically assume can be possible only at the sacrifice of merit.

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

We had an illustration of this tendency of our educational leaders in a recent magazine article by President Eliot of Harvard University, in which he wrote: "The Hessian country girl probably wears her grandmother's woolen petticoats, and they are as good and handsome as sixty years ago. A Scotch shepherd's all-wool plaid withstands the wind and rain for a lifetime," and he adds a eulogy of the old Swiss porter's overcoat, which has kept him warm and dry for twenty-five years. In sharp contrast with these examples the president speaks contemptuously of the "all cotton" clothing of an American rural community that costs about ten dollars a suit, fades promptly, and is gone in a season. His obvious moral is that we are living in the age of "cheap and nasty" clothing; that it wears out about as fast as the rapidly revolving machinery of the nineteenth century can produce it; that all that was formerly made in the way of textiles, by the more laborious hand processes, was better than anything now produced by our much boasted modern machinery.

President Eliot of Harvard

Hand-made cloths

Now it is perfectly true that the hand-spun

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

and hand-woven fabrics of the last century possessed an enduring quality not inherent in most of our lighter and more delicate cloths. But it is equally true that if there were not some apparent and unmistakable gain in the modern machine-made fabric, the backwoods farmers' wives and villagers, who formerly made their own clothing in their own homes, would have continued to make it, notwithstanding the advent of the machine. Cheaper than formerly, and immensely cheaper, the materials of clothing undoubtedly are; and many of them are cheaper and poorer than they ought to be, although it is the market that determines the quality of the very poorest stuff that is made. The woman who wants a cheap dress can get it now, and that she could not do in the days that are gone. But the woman who wants a handsome dress, of the highest quality and the most perfect construction, can also get it, at a price very much less than any material of like quality would have cost in the old days. While the tendency with the cheapest goods may be constantly towards a poorer quality, according to the price one is willing or able to pay, the tendency in the other grades is constantly towards more perfect workmanship, with better all-round results. The perfecting of textile machinery, even when it tends to enormous

increase in output and constantly reducing costs of manufacture, is always in the direction of a better article. Even so simple a thing as a worsted yarn will illustrate this constant tendency towards improvement. The yarns formerly made would never have stood the test of the rapid loom work to which they are now subjected, because the machinery which spun them was not capable of making an absolutely uniform skein, each part of which was as perfect as every other part.

It is a popular habit to indulge in generalizations, based upon isolated illustrations, which ignore the real economic relation of modern methods of cloth-making to the social status of the whole people. It implies that with all that has been gained, something has been lost, without which we are on the whole the losers in consequence of these modern methods. It is not possible to take that view, so far as it concerns the clothing of the people, without ignoring certain historical facts having to do with the every-day life of the people. The long life of the better grade of garments worn by our ancestors was due chiefly to the fact that they did not wear them as all clothes are worn to-day. Before the advent of machine-made cloth, the higher priced garments were so expensive that they were carefully preserved

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

among the other family valuables, and only brought out on stated occasions, to be carefully packed away again in their cedar boxes and other moth-protecting coverings. They lasted because they were cared for; and they were cared for because they were too costly to be worn out and replaced every year or two, as at present. Thus is explained the presence, in the closets and attics of so many people, of the great-grandmother's wedding dress and slippers, of the curious blue broadcloth dress suit, with its brass buttons and tight-fitting sleeves, and the other paraphernalia of antique costuming which serve to give color and zest to our modern theatrical and minuet entertainments. They have been handed down to this generation as family relics, because they were too precious in their own day to be treated as necessities of life.

McMaster quoted

Mr. McMaster, in his admirable history, writes that "the colonial New Englander had for the Sabbath and state occasions a suit of broadcloth or corduroy which lasted him a lifetime, and was at length bequeathed, little the worse for wear, with his cattle and his farm, to his son." It is an easily established fact that modern broadcloth, machine-made though it be, possesses every quality of endurance found in the broadcloth of colonial days. It is made all of wool, and wool has lost none of the virtues it

possessed two centuries ago. It only differs in that it is in every way a better and a more perfectly made fabric. The suit of clothes made from to-day's broadcloth can be handed down from generation to generation, if the owner thereof will treat it with the same scrupulous care, and never wear it except when he goes to church.

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

It is not the least of the blessings of our time that we need no longer fear to wear our best clothes because we cannot afford to replace them. They are now so cheap, in comparison with their cost in colonial days, and the wherewithal to buy them is so relatively plentiful, that our well-to-do people now give away each year clothes enough to have sufficed for several generations of their ancestors, without thought as to how many years of good service are left in them for their recipients.

The habit of decrying modern clothing, as a degenerate and inferior production to that which distinguished "the good old times," is only one of many prevalent methods of looking askance at modern progress, and philosophizing over the backward trend of civilization in certain important characteristics of social and industrial life. This habit is twin sister to another idea, tenaciously prevalent in certain ultra circles, to the effect that nothing which is made in

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

the United States is quite as good as the identically same thing which has been made in some foreign country. In no department is this notion so persistent as in that which has to do with the materials out of which our clothing is made; and nowhere, it may be added, is this widely prevalent impression so wholly without a foundation of truth upon which to rest. It is a fact well known to those in trade that a number of our best manufacturers are compelled, in order to hold the natural markets for their goods, to ticket them with foreign labels, and thus foster the impression that they are not of domestic origin. It is a common practice for well-dressed American men to pay a dollar a yard more for the cloth in the suit of clothes they are ordering, in order that they may wear what they believe to be foreign-made cloth, in blissful ignorance of the fact that it was made right here at home, and is so perfect in every particular that they will by no mischance ever know the difference. We do not wish to be understood as sanctioning this method of doing business. The pity of it is, that it should ever be necessary as an antidote to the unnatural prejudice of certain native-born Americans to the productions of home industry.

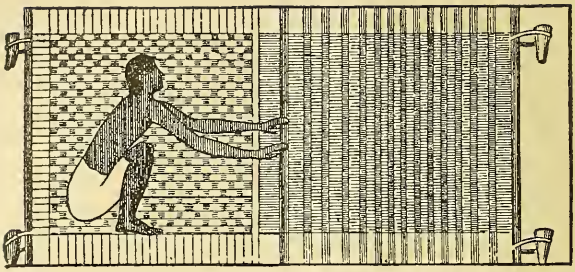
Foreign labels

It is narrated that in the year 1770, or thereabouts, prompted by the popular resentment

aroused by the Stamp Act of 1766, the graduates of Harvard College appeared on the commencement stage clad from head to foot in garments whose material was made wholly in the Massachusetts colony. It was their way of showing their aggressive patriotism, at a time when the mother country was bending all her resources to suppress and destroy the nascent industries of the American colonies, particularly the making of woolen cloths, which England regarded as her own special and peculiar privilege.

MECHANICAL ADVANCE OF THE WORSTED MANUFACTURE

A little more of the spirit and purpose which marked that demonstration of the Harvard boys in 1770 would not be amiss in these closing years of the nineteenth century. We stand in need of some renewal of the colonial faith in ourselves and our destiny, to help the present generation to a better understanding of the fact that in the social and industrial evolution now advancing so rapidly, all things are working together for the greatest good of the greatest number; — and more certainly, more rapidly, more hopefully, in our own beloved country than in any other.



An Ancient Egyptian Weaver. B. C. 2000

(From Sir Gardner Wilkinson's "Manners and Customs of the Ancient Egyptians")

CHAPTER VIII

SUMMARY

IN concluding this cursory sketch of the history and future possibilities of the worsted manufacture in the United States, we will endeavor to put the whole thing in a nutshell by summarizing, in as few words as possible, the several advantages which seem likely to come to that industry in this country by reason of the establishment of the Arlington Mills top mill. The reader of the preceding pages will have discovered that this enterprise is the only one of its exact type in the world, because, in offering tops to the trade, it combines the work of the merchant and the manu-

A unique enterprise

facturer in a manner done in no other country. He will have learned that it is a conservative step in the direction of specialization in the worsted industry, — an advance movement which appeals to the worsted spinner by reason of the distinct advantages it offers him; which appeals to the general public by reason of what it promises to accomplish in the diversification and development of an industry; and which appeals to the people of New England especially, because it will be instrumental in increasing the employment of capital and labor in this community. SUMMARY

The benefits to the worsted manufacture which seem likely to follow may be summarized as follows: —

I. It will enable existing worsted spinning mills to diversify their product by buying different grades and qualities of top which their machinery may not be fitted to produce, or may be inadequate to produce in sufficient quantities. Diversification of product

These worsted spinners can, if they choose, increase their spinning and doubling capacity at a comparatively small outlay for machinery and buildings. Where their preparatory machinery may need renewal, they can fill the space it occupies with new spinning machinery, to much greater advantage than by renewing their old preparatory machinery.

SUMMARY

II. The top-mill enterprise of the Arlington Mills offers an inducement for the starting of new spinning-mill plants.

More spinning mills.

a. Because such plants can be started with a comparatively small capital. There will be no necessity for the investment of the relatively large amount of capital hitherto required for the preparatory machinery equipment.

b. Because there will be no longer necessity for employing the amount of capital needed for purchasing and carrying stocks of wool in sufficient quantities and sorts for the needs of the spinner.

c. Because the spinner will not require any mercantile or manufacturing skill outside of or beyond himself. In other words, he need no longer be merchant as well as manufacturer, but can concentrate his whole attention upon the business of spinning yarns.

Uniformity of stock

III. A third gain will be in uniformity of stock, secured by the opportunity to purchase tops of a uniform standard of quality; there will also be a gain in the uniformity of the preparation of the stock, — quite as essential as uniformity in the stock itself.

IV. It will be easy to obtain at short notice all grades and qualities of tops, permitting quick changes of product.

V. Purchases can be confined to the exact quantities necessary to fill particular orders, thus avoiding the necessity of carrying a large assortment of raw material of dissimilar character; the spinner, in fact, will be obliged to carry no more stock than is actually necessary for operating his machinery. SUMMARY Smaller stock of materials

VI. Knowing just the quantity of top purchased and the price paid, it will be possible to figure the costs of subsequent production much more closely than at present.

VII. The time elapsing between the purchase of stock and the receipt of payment for the finished goods will be reduced by about one half, thus permitting a larger business on a smaller capital, independent of the smaller capital required by reason of the smaller plant necessary. Quicker turning of capital

VIII. The ordinary business risks of manufacturing will be reduced to the minimum by the operation of each and all of the above causes. Less business risk

IX. The combination of all these results must work for the production of better yarns and a higher quality of manufactured goods at a better profit to the manufacturer.

By the above propositions it is obvious that a worsted spinner can equip a spinning mill,

without preparing or top-making machinery, at a comparatively small expense;

That he can make a contract with the Arlington Mills for a periodical and regular supply of tops for any given time;

That such tops will be of a quality to insure the spinner the best possible market prices for his yarn, and at a cost for top, all things being considered, as low as, if not lower than he would be able to produce the top himself;

That the spinner can stock his mill at a minimum employment of capital;

That he can arrange his supply in such a way that he will only require in stock what is actually needed for running his machinery;

That, whenever business cannot be carried on at a profit, he can close his spinning mill and be subject, while it is idle, to minimum expenses;

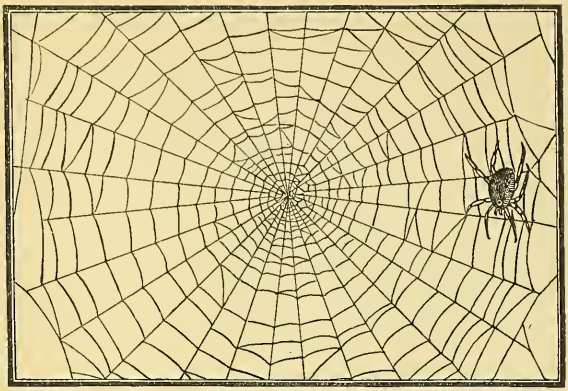
That he can secure an option on his tops for a time long enough to enable him to sell his yarn before completing his purchase of tops.

This will reduce the risks of business to a minimum. It will reduce the business practically to a mathematical certainty, because the spinner runs no risk whatever in making his purchase. Given a specific quantity of tops, he knows exactly how many pounds of yarn can be produced from them, and the actual cost

to him of making such yarn; and there will be no difficulty whatever in making his sales, under normal conditions, upon an actual and not a theoretical basis.

If the deductions above are well founded, the new enterprise must prove an advantage to all concerned.

APPENDICES



A Spinner whose Works never shut down

APPENDIX A

THE PRODUCTS OF THE ARLINGTON MILLS

With the development of the Arlington Mills, the variety of their products has correspondingly increased. It has always been their aim to provide for the people at large, and this has led them gradually into broadening the scope of their work. In addition to the manufacture of a great variety of worsted and cotton yarns, they have facilities for the manufacture of nearly every kind of worsted fabric for women's and children's wear; whether the weave be plain or fancy, the colors solid or combined in plaids, figures, or stripes; whether the fabric be made of white yarns, for subsequent

PRODUCTS OF THE ARLINGTON MILLS

piece dyeing, or of yarns dyed in the wool or top, commonly designated as slub dyed; whether the width be 36 inches or 54 inches, or the weight 3 ounces or 8 ounces to the square yard.

The Arlington Mills dress goods, both in the cheaper varieties and in the finer fabrics, are recognized by the trade at large as being equal to the best products of the looms of Europe. The mills have a representative abroad, who visits the great centres of fashion, and so keeps the home office in touch with the newest creations of foreign designers and the trend of ideas among those who cater to fashion. This knowledge is supplemented by a corps of competent designers in the mill and principal offices.

Perhaps the most characteristic feature of this branch of the Arlington Mills business is the making of specialties for the trade on orders, which have heretofore been made solely in Europe. This business has lately grown into large proportions. Importers and others are enabled to place orders for novelties in cloths, with the understanding that the same article, or any article so closely resembling it as to conflict with its sale, will not be made by the Arlington Mills for other houses. In this way the individuality of each firm as to taste or design can be reserved to its own use and advantage.

The products of the Arlington Mills looms may be roughly divided into two great classes, the general subdivisions under each of which are indicated below.

A. Women's and Children's Dress Goods

These goods are sold to the general dry-goods jobbing trade. The greater part of the product is made solely on orders, taken months in advance from samples made from original designs. This class of goods includes, in addition to a great variety of plain and staple goods, such as All Wool Serges and Cheviots, Cotton Warp Cashmeres, plain Alpaca and Mohair fabrics, an immense variety of fancy woven effects produced by a union of the Jacquard and box loom, combining cotton yarns in their natural state, and also in the silk-finished state (which can hardly be distinguished from silk), silk yarns, and worsted yarns in numberless colorings. In fact, the Arlington Mills have the capacity for making any kind of women's and children's dress goods that it is possible to weave on power looms. A not inconsiderable feature of the business is the production of cloths suitable for manufacturers of waterproof garments.

B. Coat Linings

These goods are sold exclusively on orders to wholesale houses, which distribute them to clothiers and tailors. The business is large, and rapidly increasing under existing conditions. These coat linings comprise a great variety of weaves and colorings, and are produced by combining cotton warps with the finest Australian wool, as well as with what are

known as lustre wools (which are of English origin) and mohair and alpaca. They are in universal use for the lining of men's wear garments.

II

From the manufacture of the finished product, we now turn to a branch of the business which is of equal importance, — the manufacture of tops, rovings, and yarns for sale, in addition to what are required for their own consumption. These may be divided into four great classes.

A. Worsted Tops

In the manufacture of these, nearly all the varieties of combing wools grown in the world are used: Australian Merino and Crossbred wools; South American Merino and Crossbred wools; Cape Merino wools; Merino and Crossbred wools grown in the United States and Territories; the lustrous wools of pure English blood; Mohair from Asiatic Turkey and Alpaca from the Andes. Tops made of all these varieties of fibres are offered to worsted spinners at the most advantageous prices and terms.

B. Worsted Yarns

The Arlington Mills offer for sale yarns made on both the English and French systems of spinning, from tops already described. While there is a great variety of uses to which these yarns are put, the principal sales are to the weavers of men's wear goods and to the knitters of underwear and hosiery. These yarns are made in all practical degrees of fineness,

in the gray, in solid colors, in fancy mixtures, double and twists, and Jasper effects, and are delivered to the purchaser in any form he may require for subsequent use.

The most striking characteristic of the Arlington Mills' yarns used for men's wear goods is that they are fast in color. By this we mean that the colors do not change during the process of scouring, nor do they change after the goods are manufactured, by exposure to the light. In this most essential feature they are considered superior to any foreign yarns.

Included in the worsted yarns are Lustre, Mohair, and Alpaca yarns, in their natural state, and also colored or genapped.

C. Cotton Yarns

The Arlington Mills also manufacture, in addition to their own requirements, combed cotton yarns for sale to weavers, loom harness manufacturers, knitters, and thread and lace curtain manufacturers. These yarns are manufactured from the longest staple Egyptian, American, and Sea Island cottons. They are spun in all numbers up to No. 100, in single and two or more ply, and are delivered in all the varieties of forms required by the purchaser for subsequent use.

The Sea Island yarns are sold largely to the manufacturers of bicycle tire cloth, which is the base of the rubber bicycle tire. Until within a very short time, all of the brass bobbin yarn used by lace manufacturers in the United States has been imported from England, but now the Arlington Mills are fur-

nishing such yarns, equal in every respect to the best of those imported.

The most recent development of the cotton yarn trade is the process of Mercerizing. By this process cotton yarns are given a brilliant lustre almost equal to that of silk, and can be substituted for silk in many classes of goods. The mills are now prepared to furnish these yarns in quantity.

D. Worsted Merino Yarns

The Merino yarns of commerce are made of carded wool and cotton, mixed together in the process of carding. It is a new departure to make the same character of yarns of both combed wool and combed cotton, blended in such proportions as the consumer may require for his trade. The Arlington Mills are engaged in this business and offer such yarns for sale. While the immediate demand is for knitted underwear, where such a mixture has an advantage over all-wool yarns, in that garments so made will shrink less in washing, yet a large demand is expected for them from all classes of weavers, who wish to combine cheapness, lightness, and mixed effects in their fabrics. By the use of these yarns, contrasting colors can be secured in a simple and economical way.

APPENDIX B

COLUMBUS SIGHTING AMERICA

The picture on the following page is a reproduction of a work designed and woven at the Arlington Mills, as a souvenir of the four hundredth anniversary of the discovery of America by Columbus, and a memorial of the great World's Columbian Exposition. It conveys a vivid impression of the possibilities of modern skill and machinery in the way of artistic weaving.

The original painting, of which this is a copy, is in the National Gallery at Berlin, Germany, and has a world-wide reputation. It is painted on canvas, and is 4 feet by 4 feet 7 inches. The artist was Herman Freihold Plüddeman, a famous painter of historical subjects. He was born at Kolberg, Germany, July 17, 1809, and died in Dresden, June 24, 1868. He was first instructed in Magdeburg by Lieg, then a pupil of Begas, in Berlin, and from 1831 to 1837 he was a member of Düsseldorf Academy under Schadow. While there, in the year 1836, he painted his famous picture of "Columbus Sighting America." He remained at Düsseldorf until 1848, when he removed to Dresden, where he continued to live until his death in 1868. He painted chiefly subjects from mediæval history, saga, and poetry, in the spirit of the romanticists. He was also a well-known

COLUMBUS SIGHTING AMERICA

illustrator of several popular works, but he seems to have made a special study of the great events in the life of Columbus, for among his works are the following: Columbus Sighting America (1836); Death of Columbus (1840); Entry of Columbus into Barcelona (1842); Columbus at La Rabida (1845); Columbus in Chains Landing at Cadiz (1848); Columbus Disputing with the Junta at Salamanca (1856).

The following facts are of interest in connection with the preparation, design, and weaving of the picture, and will give some idea of the magnitude of the work involved.

A photograph of an engraving, made from the original painting, was first taken, and from that photograph the weaving design was made on an enlarged scale upon cross-section paper, each square of which is intended to represent the position of a thread in the warp and filling in the cloth. This design sheet was 6 feet 5 inches wide and 8 feet 9 inches high, and was a picture in itself, the figures being larger than life size.

The loom used was an ordinary power loom with the Jacquard attachment. The Jacquard machine was the invention of a native of Lyons, France, Joseph Marie Jacquard, whose name it bears. His attention was first directed to the subject of mechanical invention by seeing in a newspaper the offer of a reward for a machine for making nets. He produced the machine, but did not claim the reward. The circumstances becoming known to some persons in authority in Paris, Jacquard was sent for, intro-

COLVMBVS SIGHTING AMERICA

DESIGNED AND WOVEN AT THE

ARLINGTON MILLS

LAWRENCE MASSACHVSETTS V.S.A.

duced to Napoleon, and was employed in correcting the defects of a loom belonging to the state. Jacquard stated that he could produce the effects intended to be produced on this loom by far simpler means, and as a result he made, in 1801, the machine bearing his name. He returned to Lyons with a pension of one thousand crowns, but his invention was regarded with so much distrust and jealousy by the weavers that they attempted to suppress it by violent means.

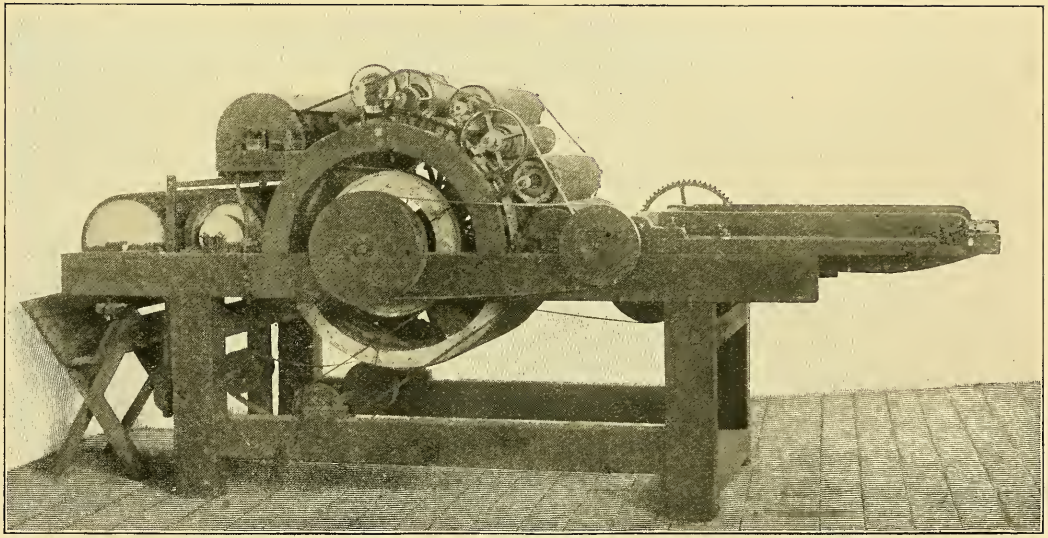
The object of the Jacquard loom is to facilitate the production of elaborate designs upon textile fabrics. The Jacquard "engine," as it is called, is placed above the loom, and its object is to so separate the threads of the warp that the shuttle, in passing between them with the filling, will produce the desired design. Each warp thread is passed through an eye in a cord, hung in a vertical line from the Jacquard engine. In the engine is a revolving square bar, perforated with holes, and each hole represents a thread in the warp. By means of a mechanical attachment of levers and hooks, these vertical cords, and the warp threads attached, are lifted by the action of the ends of the levers pressing against the revolving square bar. If a hole is opposite a lever the corresponding warp thread is lifted, but if the hole were covered, the thread would not be lifted. A long series of pasteboard cards are strung together, each card being the size of one face of the revolving bar, and by means of the mechanism these cards are passed in succession over the bar and in front of the ends of the levers, and wherever

a hole is punched in a card, in front of a hole in the bar, the end of the lever opposite that point passes through the hole, and in consequence, by the action of the levers and hooks, the warp thread is lifted. By means of these cards and the holes punched in them the motion of the warp threads is regulated, and the number of holes and cards necessary depends on the design to be woven.

The loom upon which this picture was woven was 62 inches wide, driven by steam power, and operated by one man. It was fitted up with four Jacquard engines; two of these had 400 hooks and cords, and two of them 304 each. The engines were placed back to back, the cards running in front of, as well as back of, the loom, and all four engines operated at one and the same time upon the warp.

Number of cards used	21,024
Number of holes in cards	4,162,750
Length of cards, placed end to end	$4\frac{8}{10}$ miles
Area covered by cards	5,140 sq. ft., or floor space over 70 ft. sq.
Weight of cards	875 lbs.
Ends of warp per inch	117
Total ends of warp	3,850
Picks per inch, white yarn	120
Picks per inch, colored yarn	120
Total picks per inch	240
Speed of loom, picks per minute	100
Total picks in each picture	5,250

The pictures are made of the finest silk yarn, and were woven two abreast in the loom, each picture being $16\frac{3}{8}$ in. by $22\frac{3}{4}$ in. in size, and the time required



THE FIRST CARDING MACHINE BUILT IN AMERICA, 1792

to weave the two pictures was one hour and one quarter.

COLUMBUS SIGHTING AMERICA

The silk yarn used in each picture, if extended in a straight line, would measure 10,814 feet, or a little over two miles.

APPENDIX C

THE FIRST CARDING ENGINE BUILT IN AMERICA

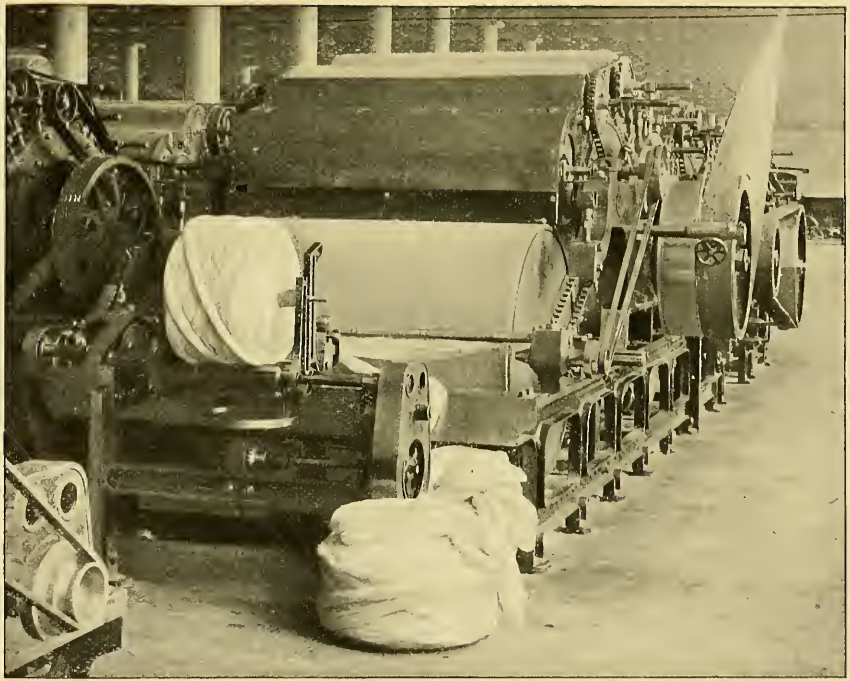
The picture of a primitive carding engine, which is published by the courtesy of the Davis & Furber Machine Company, of Andover, Mass., is a reproduction of what is undoubtedly the oldest machine of this description now in existence in the United States, and probably the very first carding engine that was ever used in the wool manufacture in this country. While there is no doubt as to its identity, some question exists as to whether it was built in the United States or in England. The facts, so far as known, are given in the following letter from the Davis & Furber Machine Co.

North Andover, Mass., Nov. 26, 1897.

Mr. William Whitman, *Treasurer Arlington Mills* : —

Dear Sir, — Agreeable to your request, we give you copy of what data we have relating to the old carding machine now in our possession. This machine was on exhibition at the Mechanics' Fair in Boston in 1890, and to it was attached a card bearing the following inscription : —

"The machine was built in England in 1792 ; and, as the laws at that time did not permit the exportation of textile machinery, this machine was shipped



A MODERN WORSTED CARDING ENGINE, 1897

in two parts and in different vessels, and probably called agricultural machinery. John Lees and William Marland, afterwards of Andover, Mass., crossed the ocean with one part of it, and John and Walter Scholfield in another vessel with the other part of it. It was put together in Charlestown, Mass., and run there for about three years by John Lees; also in Byfield Parish about four years by said Lees, in connection with William Bartlett, a wealthy ship-owner of Newburyport; it was afterwards run in Nashua, Jaffrey, and Marlboro, New Hampshire, by a Mr. Fiske, and for the last fifty-three years by James Townsend, of Marlboro, New Hampshire, who is now ninety-three years of age."

THE FIRST CARDING ENGINE BUILT IN AMERICA

The carding machine came into the possession of Hon. Rufus S. Frost, of Boston, and on his death was purchased by us. Subsequently, Mr. S. N. D. North, Secretary of the National Association of Wool Manufacturers, became interested in the carding machine; and in an attempt to trace its origin, received the following letter from the Hon. Royal C. Taft, of Providence, Rhode Island: —

PROVIDENCE, R. I., March 19, 1896.

S. N. D. NORTH, *Secretary:* —

DEAR SIR, — Your favor of the 17th inst. is received and noticed. Some years since I sent to Hon. Rufus S. Frost a copy of my book, "Some Notes on the Woolen Manufacture of the United States," from which resulted some correspondence relative to the first carding machine built in this country. Mr. Frost supposed that his carding machine was the one referred to in my narrative, and that it was imported from England. His authority, as

he admitted, was only a statement which he supposed to be correct.

Mr. Frost was quite positive that he owned the Scholfield machine, and the only doubt he had was as to whether it was made in England or at Newburyport, but he came to the conclusion that it was made at the latter place.

I myself have no doubt that he has the Scholfield machine, as John Scholfield left the company at Newburyport in operation with a new manager, and started a small mill in Stonington, Ct., where it is presumed he built new machinery, the building and starting of carding machines having been done by both Arthur and John Scholfield in several places.

The evidence upon which I based my statement was given me by James Scholfield in 1872, when he was eighty-eight years old, and verified in 1882, when I rewrote the book. James Scholfield was nine years old when the Scholfields moved to Newburyport, and eleven years old when the Byfield factory was started. Mr. Scholfield was perfectly clear in his recollection, and positive that the machine was built under his father's direction at Newburyport. Mr. Frost was positive that it was the first machine, but in face of the direct evidence I had from Mr. Scholfield, doubted if he was correct in claiming the machine to have been made in England. Our correspondence was only a short time before the decease of Mr. Frost. What led me and the Scholfields to our conclusion was a written statement made by a grandson of John Scholfield, who was desirous his grandfather should receive the credit which was his due; and accordingly prepared and left behind him the substance of what I certified through James Scholfield. It was a common subject of talk among the Scholfield family, several of whom have written me thanking me for the

investigation which I made, and for giving credit to their grandfather for what they had all known from him and his children.

THE FIRST CARDING ENGINE BUILT IN AMERICA

Royal C. Taft.

From which you will see there is some doubt as to the real history of this machine.

Very respectfully yours,

Davis & Furber Machine Co.

The advance of one hundred years in carding machinery may be judged by a study of the picture of the Scholfield carding engine in comparison with that of the modern card which is given herewith.

APPENDIX D

FACTS ABOUT THE PROPERTY OF THE ARLINGTON MILLS

THE land comprises 74.9 acres, divided as follows: —

Land in mill yards	34.7 acres.
Land in Methuen	18.8 "
Land under pond and river	21.4 "

The floor space of the buildings is as follows: —

Worsted Department

	Area of Floor Space.
Storehouse	73.140 sq. ft.
Solvent Plant	11.961 "
Top Mill	370.458 "
Spinning Mills	304.838 "
Dyeing and Finishing Mills	96.391 "
Weaving and Dressing Rooms	150.207 "
Repair Shop	25.521 "
	1,032.516 sq. ft.

Cotton Department

	Area of Floor Space.
Storehouse	23.844 sq. ft.
Spinning Mill	174.225 "
Twisting Mill	63.126 "
	261.195 sq. ft.

Worsted Department, floor space .	23.7 acres.
Cotton Department, floor space .	6.0 "
Total floor space	29.7 acres.
Total Horse Power	8,000 H. P.

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